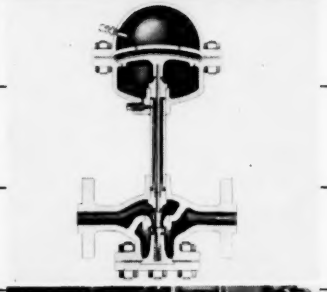
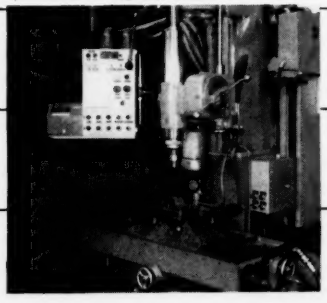
INSTRUMENTS and AUTOMATION

Digital Differential Analyzers . . . page 1105



Pneumatically Loaded Regulators . . . page 1090



Numerically Controlled Positioning Table . . . page 1110

THE INSTRUMENT INDUSTRY ..... page 1122

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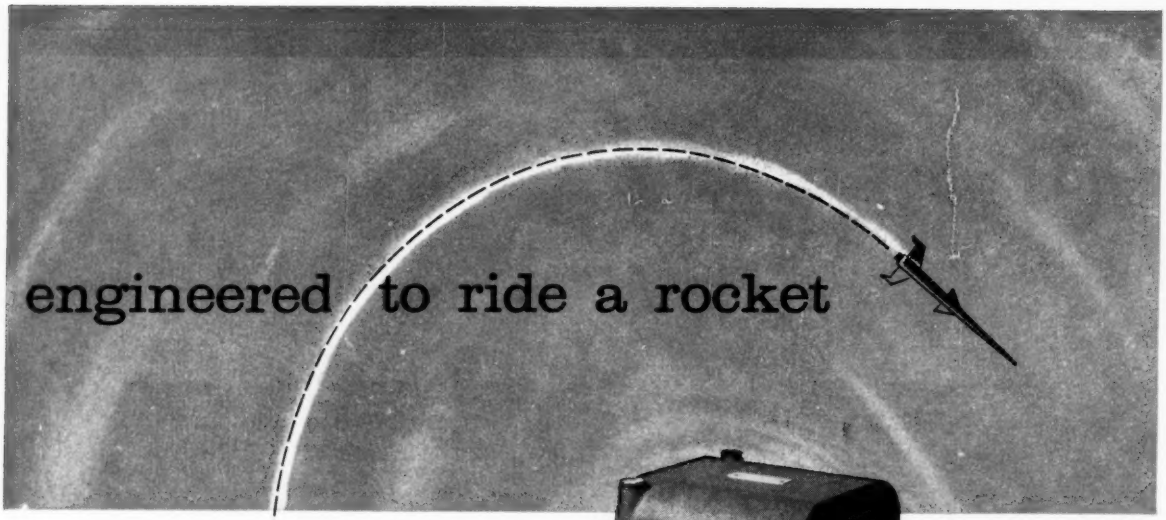
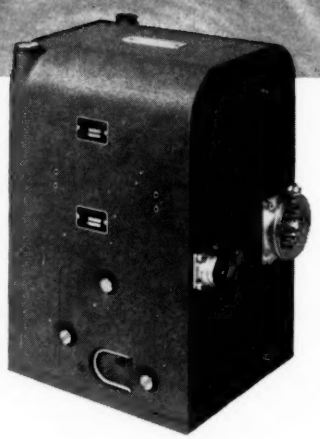
JUNE 1957 Instruments & Automation



engineered to ride a rocket



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561 SPECIFICATIONS

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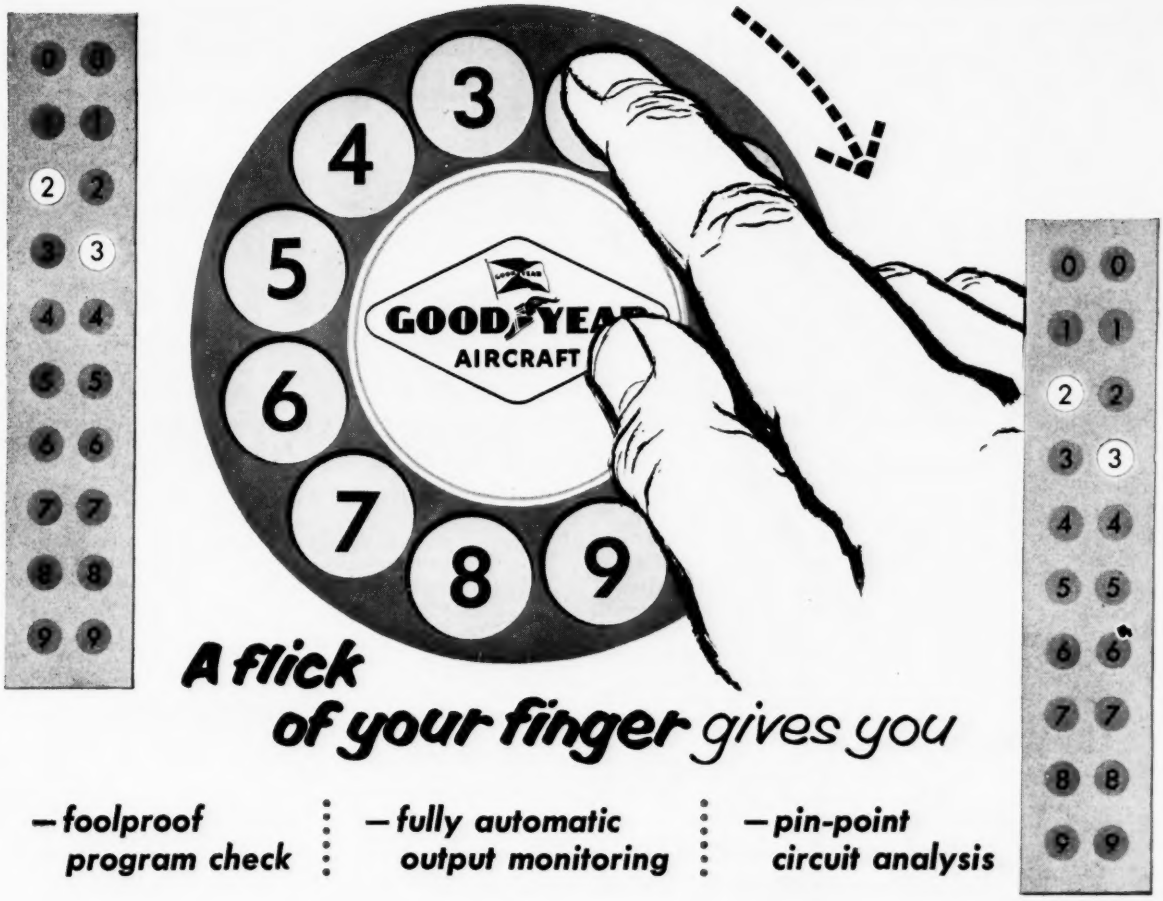

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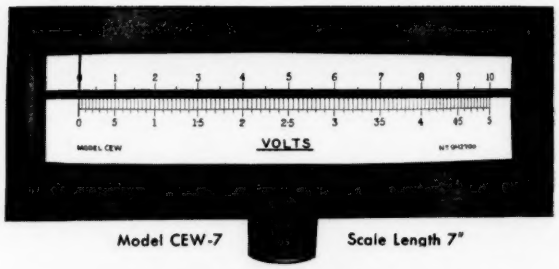

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INSTRUMENTS and AUTOMATION

Volume 30, No. 6
June 1957

EDITED FOR USERS OF MEASUREMENT AND CONTROL INSTRUMENTS

Editorial

Report of the President to the 39th Annual Meeting of the Scientific Apparatus Makers of America 1081

Feature Articles

Pneumatically Loaded Regulators 1090
C. S. Beard

Boiler Test via a Digital Data System 1096
J. H. Bail, C. E. Jones and H. T. Hoffman

Electronic Circuitry 1102
Charles F. Kezer and Milton H. Aronson

Digital Differential Analyzers 1105
Martin L. Klein, Frank K. Williams, Harry C. Morgan, and Shigeru Ochi

Numerically Controlled Positioning Table 1110
Bernard Resnick and Miles Hayes

University Research⇄Instrumentation 1120

The Instrument Industry—An Economic Report 1122
Richard Rimbach

Combined Analog and Digital Systems—Why, When, and How 1126
John H. McLeod and Robert M. Leger

Journal of the Southern California Meter Association

Orifice-Meter Maintenance 1132
Dale D. Koepke

The Simulation Council Newsletter 1135

Other Regular Features

Letters to the Editor 1012
Inquiries 1026
Trends 1033
Panhandle Pete 1034
News 1036
Stock Report 1052
Biographies of Significance 1071
New Instruments 1142
Briefs 1192
New Literature 1202
Searchlite Section 1214
Advertiser's Index 1216
Inquiry Card 1217

THE MAGAZINE OF INSTRUMENTATION AND AUTOMATIC CONTROL SINCE JANUARY 1928

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Letters to the editor

Editor, I&A:

We have your questionnaire concerning the 1958 *Instruments and Automation Handbook & Buyers' Guide.* We tried to fill this out to check the appropriate headings concerning meters which we make but were unable to do so because these are not correctly classified in the listing.

I started to look under meters but find no classification there. Next I looked under liquid meters, then under displacement meters, then under water meters, oil meters, chemical meters, but found no appropriate listings. Finally I see that displacement meters are listed as one kind of flow meters, under the heading of Flow Meters. This is definitely wrong and must be changed.

Meters of displacement type for measuring liquids are not flow meters.

Evidence of this incorrectness is found in your listing on page 5, column 4, item 4 wherein you say "Flow meters indicate RATE of flow." Displacement meters do not indicate rate of flow and must not be classified under flow meters no matter what supplementary explanation is given. For further information along this line see your *Handbook of Measurement and Control* chapters 5 and 6.

The description of all types of meters should appear under M for meters, rather than under flow. Displacement type gas meters should not be listed along with liquid meters as these are entirely different, are made by different manufacturers and are not at all interchangeable in use. The section in which we are interested should read as follows: METERS, LIQUID, POSITIVE DISPLACEMENT.

H. F. Barrett
Buffalo Meter Co.

The editors of the 1958 INDEX made a basic decision to index every instrument under the variable concerned—temperature, pressure, flow, etc., and NOT under the heading of meter, indicator, or other all-encompassing term. The field of instrumentation is now too broad to permit such terminology in an index of the entire field. Hence the INDEX will have the following headings:

Flow. Flowmeters indicate RATE of flow. For positive displacement or quantity flow indicators, see Flow Indicators, Positive Displacement, including rotating piston or disc, oscillating, reciprocating, rotary piston, etc.

Editor, I&A:

As the leader among manufacturers of regulators, we're quite happy to see the foremost publication in the field do a really up-to-date business paper treatise on regulation. To my knowledge, this has not been done since "Simplified Instrumentation" and "Pressure Reducing Valves, How to Select and Install Them," by John Leslie, were published nearly 10 years ago.

Robert G. Lantz
Leslie Co.

The series on "Regulators" by Chet Beard is indeed a needed work at this time. The second installment appears in this issue.

Editor, I&A:

Speaking for our 217 members of our Student Chapter, American Institute of Chemical Engineers, may we thank you for your last week's delightful talk on *Technical Editing and Instrumentation.*

Although we were blessed with brilliant presentations before this group this semester, in many conversations following your talk, our students declared yours the most interesting of the year.

We all hope that if circumstances permit, you may be able to return next year to speak before this group again.

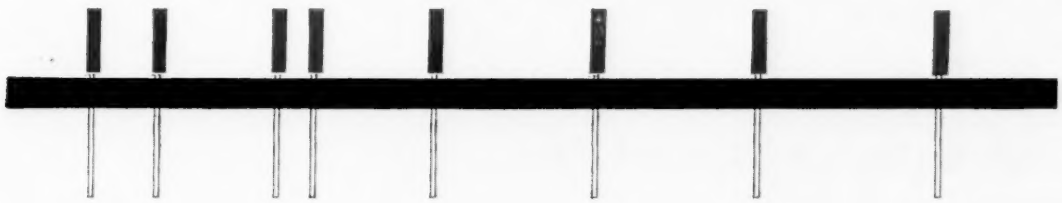
S. S. Beroes
Assistant Professor
Chemical Engineering Dept.
University of Pittsburgh

Your editors devote most of their extra-curricular speaking and "teaching" time to teachers and students, in the belief that this is the most effective way to serve the future of our field.

Editor, I&A:

I heartily agree with Everett S. Lee of Schenectady, N. Y. Mr. Bright's article, "Myths of Automation" is "worth the subscription price and more." Add to this Mr. Klein's "Un-

simple pinboard programming makes the difference...



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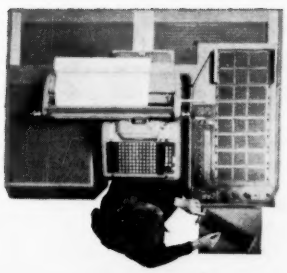

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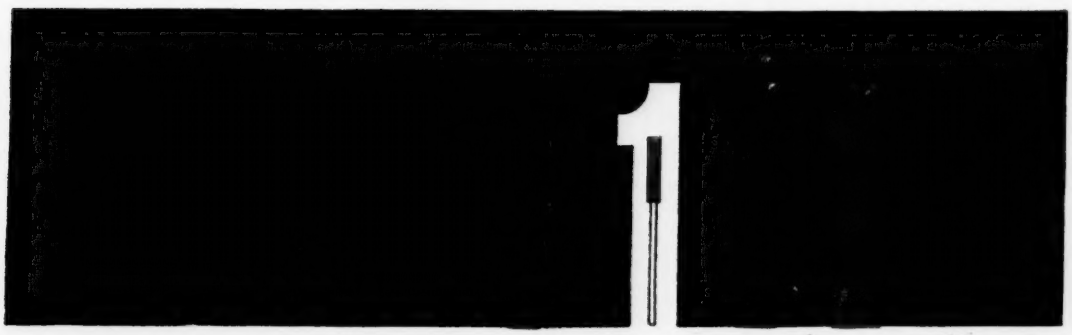

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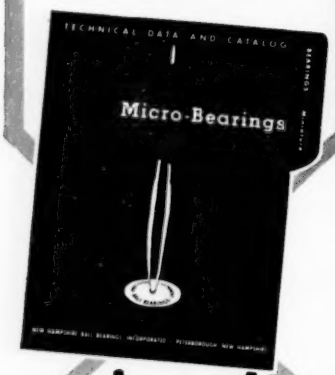

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LETTERS —CONTINUED

common Uses for Common Digital Computers" in the same issue—an over-plus of no mean proportion. I do not, as a rule, save magazine articles, but these two are the exception the proves the rule.

Also, take a bow yourself.

L. A. Cox
Barnes & Reinecke, Inc.

We hope you find such exciting material in every issue—it is there!

Editor, I&A:

You have done an excellent job in writing the hard-hitting editorial on "Education—A Multi-Level Problem" in the May issue of *I&A*.

I would, however, like to see your question on page 869 changed from "money spent" to "books read—there is a difference! !

Chas. F. Hoffmaster
Director of Vocational and Industrial Arts Education
Pittsburgh Public Schools

Editor, I&A:

Thank you for your splendid contribution to the television program over KDKA-TV on April 30. This series does a great deal toward bringing the work of our schools before the public.

It was an outstanding production and your participation as a leading figure in "Automation" made this one of the most interesting of the entire series. Your own personal performance was fine.

We realize that it involved considerable time on your part, but hope that you enjoyed the experience and felt the effort was worth-while. It was a pleasure to work with you.

Silvia Schmidt
Section on Television Education
Pittsburgh Public Schools

This half-hour program on VHF Channel 2 explained the importance of the new high-school course in Automation and Instrumentation, which will begin in Pittsburgh in Sept., 1957.

Editor, I&A:

I have read with considerable interest your presentation to the Board Committee on Education, Board of Public Education, Pittsburgh, Pa. in which you suggested an automation curriculum for high school students.

At RCA Institutes, several units are being offered in industrial electronics and automation as part of resident-school instruction. This represents the initial attempt and efforts of our school in presenting information in this expanding new field. With time, and as experienced is gained, the number of units will be expanded to include many of those that you have suggested.

Currently, the units in automation and industrial electronics are being offered at the Resident School and it is being considered to include such units in a correspondence course. I should like to determine whether you have given the automation curriculum, as you suggested, some additional thought to the inclusion of a sylabus for each unit. If such is, or will be shortly available I would appreciate receiving a copy. Your views and those of educators and people in the industry as to what should be included in such a curriculum, will be invaluable.

Waldemar Horizny
Assistant Director &
Technical Supervisor
Home Study Department
RCA Institutes, Inc.

Present intention is to prepare such sylabi.

Editor, I&A:

I have just read your "Review of 1956 Coverage Reflects Adherence to Sound Editorial Policy." I liked in particular the second paragraph. Keep up the good work.

Robt. G. Redhead
Robert G. Redhead Associates

Editor, I&A:

A recent statement by John S. Coleman, president of the Burroughs Corp. ("Hard-to-Find Office Worker Held Problem", the *Mirror News*, Los Angeles, May 13, 1957) notes that "it is increasingly difficult to procure enough help merely to man the office," and goes on to say that, although "clerical pay rate has increased some 40% . . . it has not increased the rate of productivity like factories have." He further states that "the magic words 'electronics' and 'automation' are not an immediate end-all to office problems," advising businessmen to go ahead electronically, but to go slowly.

Mr. Coleman has a point. In certain instances it is practical to have a pleasant, tape-recorded voice answer, "This is a recording. Dr. Smith cannot be reached until 11 P.M. If this is an emergency, please call Dr. Jones, Cumberland 8-900." However, this cannot replace the office secretary whose personality is counted on to discuss or refer business calls for prospective clients, make necessary appointments, etc.

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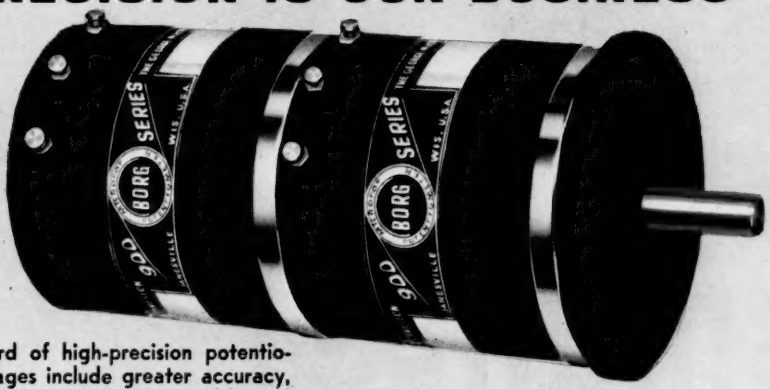

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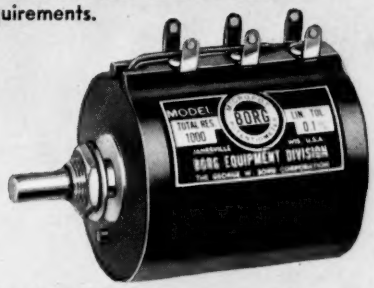

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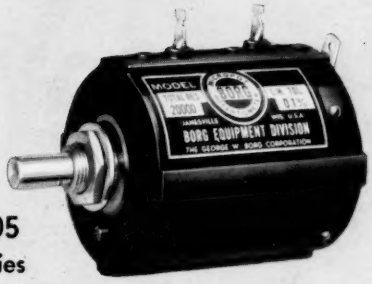

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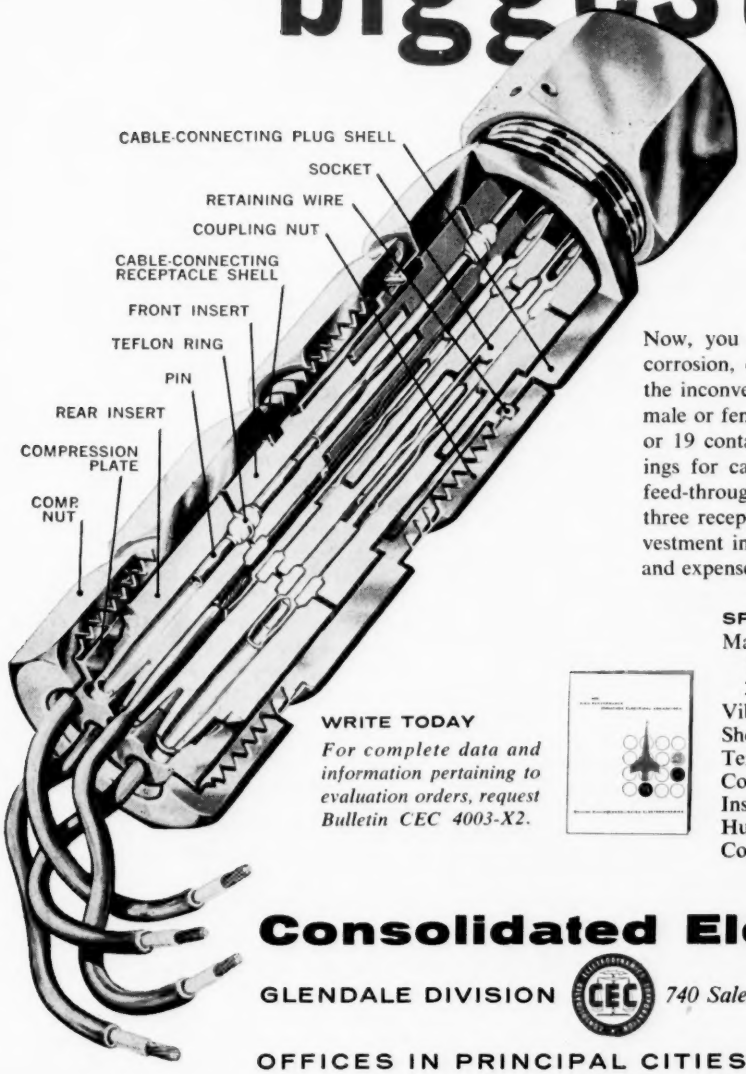

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SPECIFICATIONS

Max. Operating Voltage	
1. Sea Level	1800-v, a-c
2. 70,000 feet	800-v, a-c
Vibration	No resonances to 2000 cps
Shock	>200 g's
Temperature	−67° to + 400°F
Contact Voltage Drop	<25 mv at 5 amps
Insulation Resistance	$>10^6$ megohms
Humidity	160°F, 14 days, 95% RH
Corrosion	Salt spray per QQ-M-151a

WRITE TODAY

For complete data and information pertaining to evaluation orders, request Bulletin CEC 4003-X2.

Consolidated Electrodynamics

GLENDALE DIVISION *740 Salem Street, Glendale 3, California*

OFFICES IN PRINCIPAL CITIES THROUGHOUT THE WORLD

For more information circle 9 on inquiry card.

how many?

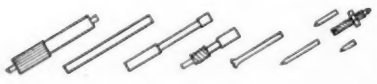
INSTRUMENT makers are using more and more Johnson pivots. Maybe you're one of them and can tell how many Johnson pivots are held in the teaspoon above.

There's a prize! No world beater, but a handy transistor portable radio to the closest guesser. In case of ties, earliest postmark will qualify.

But you needn't guess when you need precision pivots, accurately machined, scientifically hardened and polished to a metallographic finish. Direct your inquiry to Johnson for satisfaction.

Mail your estimate of the number of pivots in this regular teaspoon now to qualify for the prize. A postcard will do.

Welton V. Johnson
Engineering Company, Inc.



precision miniature parts

95 SUMMIT AVENUE

SUMMIT 6, NEW JERSEY

For more information circle **10** on inquiry card.

LETTERS—CONTINUED

It is true the electronic computer saves many manhours for math analysts and data reduction clerks by processing raw data onto punched cards, automatically correcting its own error (to a given percent). However, a certain amount of key punching is required and data still must be programmed before it is fed into the "electronic brain" for solution; then it must be interpreted and presented in a form understandable to the average engineer.

In the reception lobby electronically-operated lights can tell you whether Messrs Jones, Smith or Brown are in, but they cannot tell you whether each is (a) available, (b) wants to see you, or (c) you should be referred to someone else. This small service requires a more flexible intelligence and—let's face it! if she's pretty as well, public relations get an additional boost.

The dictawriter that records what you say and then prints it automatically with a zillion carbon copies sounds like every businessman's dream—and secretary's too! Unfortunately, it cannot correct your grammar, supply the missing word that is "right on the tip of your tongue," or follow your instructions to "write a letter to the Matthews Company about that lousy last shipment of theirs" with all the proper innuendoes.

No, Mr. Boss, as hard as they are to procure and to keep happy once you've got 'em, the secretary, clerk and receptionist will not be replaced until business' entire modus operandi is revamped. And I would be willing to wager that our great-granddaughters will be pitting their pleasant voices, winning smiles and gracious personalities against automation in the office, too!

Jacqui Callender
Secretary to the
Chief Engineer, Test Subdivision
Marquardt Aircraft Co.

Editor, I&A:

We have attempted without success to find a generally acceptable definition of the term "automation".

As the editor of a publication in this field, we thought you might have available a suitable definition. Would you be so kind as to give us your thoughts on this matter?

Clyde A. Norton
Patent Department
Remington Rand

Our definition: AUTOMATION IS THE USE OF DEVICES—MECHANICAL, PNEUMATIC, HYDRAULIC, ELECTRICAL AND ELECTRONIC—FOR PERFORMING AUTOMATIC DECISIONS AND EFFORTS.

Editor, I&A:

I cannot agree with your proposition that engineering accomplishment should be prerequisite to general discussion.

I do *not* particularly fear the "dangers" of initial ballyhoo and the inevitable expanded emotionalism attached to it. Somehow, the excesses iron themselves out in the free discussions of the public forum.

I maintain the "banner" once risen before the public must be examined, investigated. You no longer have the comfort of the obscurity of a generally non-recognized activity; you are in the limelight, and there is no retreat.

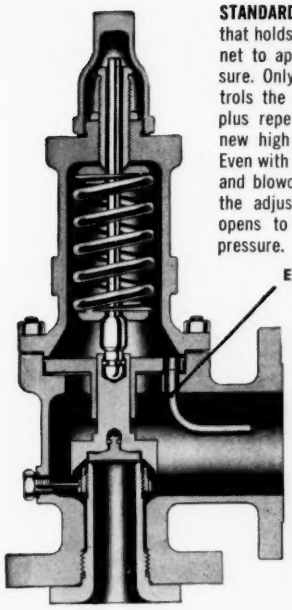
I think it is up to the Automation people to wade in and raise the many significant questions themselves. And if possible to attempt answers of them. The problem of unemployment fears cannot be ducked.

There are other important questions, too, that sooner or later the Automation people will have to become concerned with: (1) A revised theory of leisure. (2) The new requirements in general and special education. (3) Government aid for large scale development in certain areas of Automation. (4) Government policies in relation to consumers interests, as well as price problems, tax questions, etc.

Jerome Zeitlin
Bayonne, N. J.

You corroborate our main thesis. You show how present discussions are casting automation as causal factor in the national problems of security, employment, taxation, economics, leisure, etc., etc. The stark fact of the matter is that these problems are wholly within the responsibility of others. For example, a misdirected taxation policy can certainly throw our economy into a recession, at which time—in part because of the many discussions which you are calling for—everyone may have been convinced that automation was responsible.

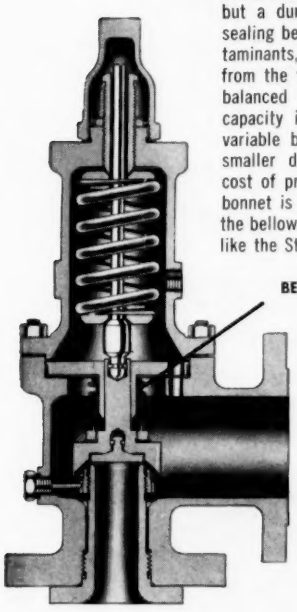
We in the automation field will accept final responsibility for production efficiency; we refuse to accept complete responsibility for the economic, political, social and moral health of the country—or to be the scapegoat for the failures of those who do have the responsibility in these fields—the economists, religious leaders, teachers, and elected legislators in particular.



STANDARD VALVE. Note the eductor tube that holds the pressure in the valve bonnet to approximately atmospheric pressure. Only the force of the spring controls the valve. Far better valve action plus repetitive flow capacity assure a new high in operational dependability. Even with repeated popping, set pressure and blowdown are consistent. Whatever the adjusting ring position, the valve opens to full capacity at 10% overpressure.

LOOK INSIDE

before you buy another safety relief valve



BELLOWS VALVE. Similar to the Standard, but a durable, two-ply stainless steel sealing bellows effectively isolates contaminants, corrosion or viscous fluids from the working parts. The bellows is balanced with the seating surface — capacity is less seriously affected by variable back pressure, so the use of smaller discharge piping reduces the cost of pressure-relieving systems. The bonnet is vented to the atmosphere. If the bellows ruptures, the valve operates like the Standard valve.

CERTIFIED AND APPROVED. Both Standard and Bellows Valves are approved under ASME Unfired Pressure Vessel Codes and are certified by the National Board of Boiler and Pressure Vessel Inspectors.

LOOK INSIDE the Consolidated Safety Relief Valve. Fewer functional parts and precision machining and alignment of parts assure long valve life and less maintenance. Economical "2 in 1" design permits the Standard valve to be converted to the Bellows type right in your own shop.

There is only one adjusting ring—it can be set easily *before* valve installation to obtain peak performance at 4-5% blowdown. *Full-rated relieving capacity* is certain at all positions of the ring because a fixed maximum secondary orifice provides full lift at 10% over-pressure. *Valve action is consistently positive* even where "superimposed" back pressure is in the relieving system.

The temperature-compensating disc eliminates seat distortion caused by temperature-induced stresses — always seats tightly even when reasonable strains of unanchored discharge piping are present. A minimum guiding area is provided to align the seating surfaces — less chance of a sticking disc holder when corrosion or contamination build up on the guiding surfaces. The seating surfaces are optically-ground flat for easier, more economical servicing.

The contours of the huddling chamber and secondary orifice take full advantage of the stream pressure and kinetic forces. No other valve has this safety feature. Note the low placement of the threaded section that holds the nozzle in the valve. It assures high resistance to discharge piping strains — no leakage resulting from strain induced into the nozzle.

BE SURE OF ABSOLUTE PROTECTION for personnel and equipment — plus low maintenance. Select Consolidated Safety Relief Valves. Full range of sizes and pressures available with standardized inlet and outlet face-to-face dimensions for easy interchangeability with the valves of some other manufacturers. *Write for Catalog 1900.*

In Canada: *Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario.*

CONSOLIDATED SAFETY RELIEF VALVES

A product of **MANNING, MAXWELL & MOORE, INC.** TULSA, OKLAHOMA

MAKERS OF 'AMERICAN' INDUSTRIAL INSTRUMENTS, 'ASHCROFT' GAUGES, 'CONSOLIDATED' SAFETY VALVES, 'AMERICAN-MICROSEN' INDUSTRIAL ELECTRONIC INSTRUMENTS, *Stratford, Conn.* 'HANCOCK' VALVES, *Watertown, Mass.* 'CONSOLIDATED' SAFETY RELIEF VALVES, *Tulsa, Okla.* AIRCRAFT CONTROL PRODUCTS, *Danbury, Conn. and Inglewood, Calif.* "SHAW-BOX" AND 'LOAD LIFTER' CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES, *Muskegon, Mich.*

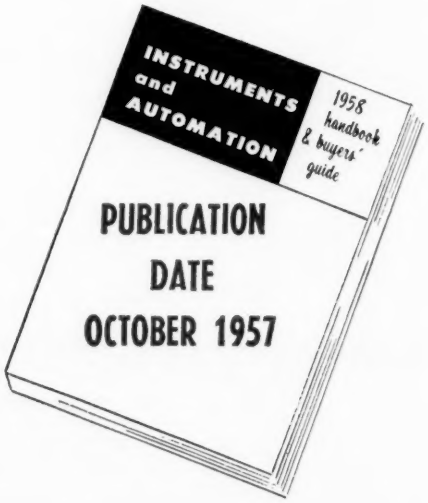
For more information circle **11** on inquiry card.

SALES MANAGERS: You route this memo—

to your ad department and agency—reminding them to plan now to advertise in the 1958 I&A Handbook & Buyers' Guide

Industry's only instrument-control equipment buying directory, the Guide offers you . . .

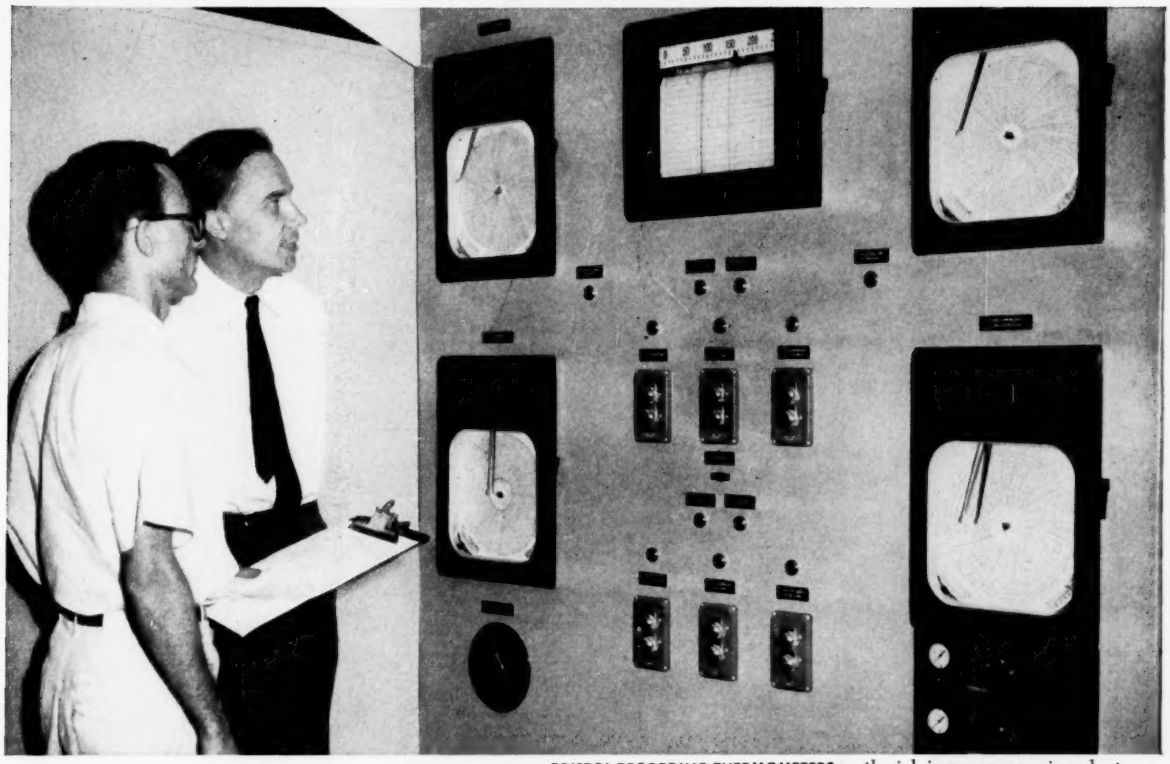
- Entree to 23,000 buyers of instrument and automatic control equipment.
- A directory listing equipment, names and addresses of 3,000 manufacturers.
- Twenty-two years experience selling to OEM and end users.
- Year 'round contact with industry's big buyers.



Reserve your ad space now. Forms close August 15-31—write:

INSTRUMENTS PUBLISHING CO., INC.
845 Ridge Ave., Pittsburgh 12, Pa., FAirfax 1-0161

WHAT'S NEWS AT BRISTOL...



BRISTOL RECORDING THERMOMETERS on the job in new processing plant.

Can you pass this recording thermometer quiz?

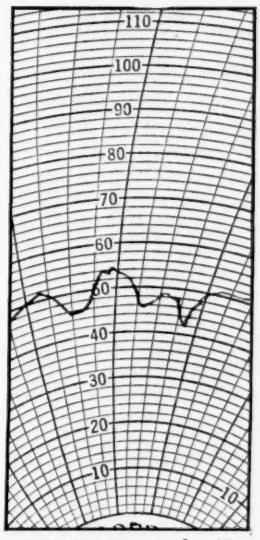
Question: ***Why do Bristol Recording Thermometers continue to lead the field?***

Answer: ***Because of Bristol's continuous research and development program. Two outstanding results of this program are:***

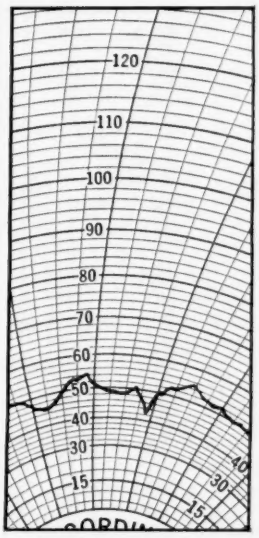
1. The 2L Uniform-Scale Vapor Pressure Thermometer which gives you all the advantages of vapor pressure thermometer actuation without the problems of the conventional non-linear increasing scale—*greatest advance in recording thermometers in 25 years.*

2. A basic improvement that eliminates ambient temperature effects. Whether you are measuring *above, below* or *at* ambient temperature, you get the same unvarying accuracy with the new Bristol Vapor-Pressure Recording Thermometers.

Want to know more? Write today for free 48-page bulletin T840 on the complete line of Bristol Recording Thermometers, liquid, vapor-pressure, and gas filled for every application. It tells all about typical installations, ranges, charts, bulbs, tubing. The Bristol Company, 113 Bristol Road, Waterbury 20, Conn.



NEW LINEAR CHART for 2L. Note easy readability due to equal chart increments.



OLD NON-LINEAR CHART. Note how scale values crowd together at bottom.

6.82

BRISTOL

TRAIL-BLAZERS IN PROCESS AUTOMATION

TRADE MARK BRISTOL'S REG. U.S. PAT. OFFICE

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

For more information circle **12** on inquiry card.

This engineer is fully equipped, with his Heiland Dynamic Recording System, to record a complete range of phenomena . . . strain, vibration, pressure, acceleration, temperature, impact and many others.

The 700-C Series Recording Oscillographs can put up to 60 traces on 12″ wide recording paper at speeds from .03 to 144 in. per sec., with frequency response from DC to 3,000 cycles per second. Power supply is 28 volts DC or 115 volts AC. Both the oscillograph and the amplifier system (either carrier or linear/integrate) may be bench, shock, or vibration mounted, or installed in a standard relay rack without modification.

Whether your measuring and recording needs are for dynamic testing of guided missiles or aircraft; structural tests of buildings, bridges or ships; performance tests of heavy machinery or electrical equipment; riding quality evaluation of automobiles, trucks, or railroad coaches; physiological or medical research; or similar applications in all fields of industry, science and engineering—it will pay you to let a Honeywell Industrial Engineer show you why the Heiland System is unmatched for sensitivity, stability, and dependable performance. Call your nearest Minneapolis-Honeywell Industrial Sales Office today . . . *and* write for Bulletins 101-A and **107-A.**

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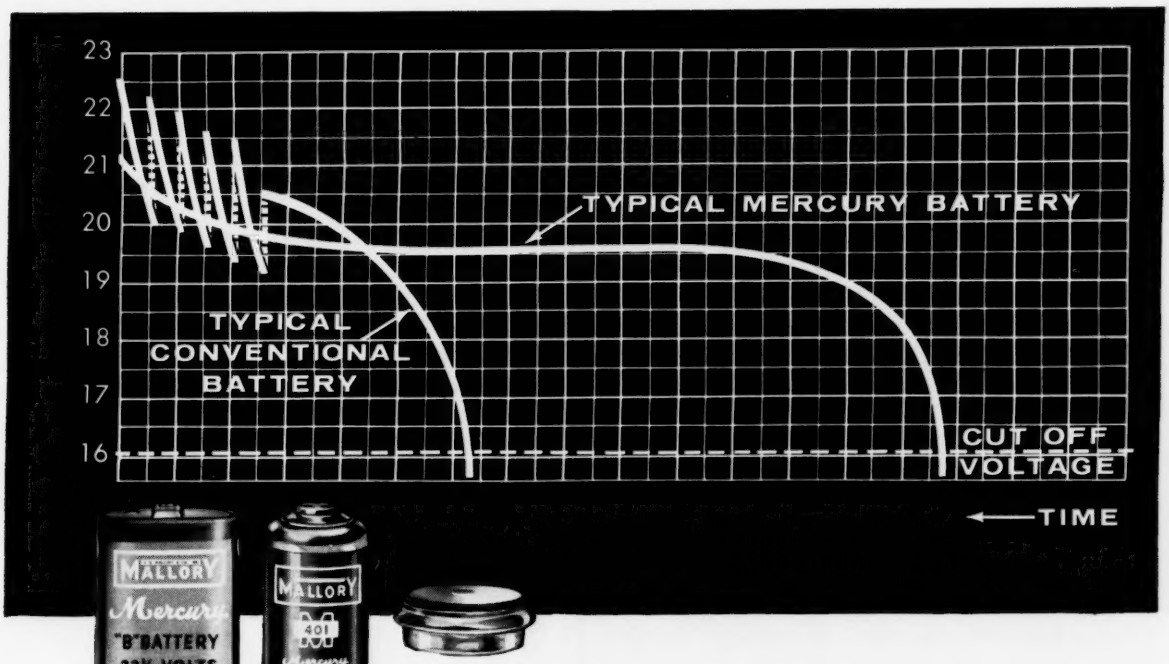
For more information circle **13** on inquiry card.



Add new values to your new products

...with Mallory Mercury Batteries

Designing dry cell powered products . . . transistor radios, "cordless" clocks, alarm systems, portable instruments.

Give them new values in performance, convenience and miniaturization, by designing around Mallory Mercury Batteries. This unique energy source, pioneered and perfected by Mallory, offers you properties never before possible.

Long life . . . several times that of conventional batteries . . . reduces need for replacement, provides unequalled dependability, gives low hourly cost.

Constant discharge gives "fade-free" performance, is ideal for use with transistors. Precise voltage is useful as a reference source in instrument and bias cell circuits.

Miniature size . . . a lot of energy in a little space . . . has made it possible to shrink the size of equipment with self contained power to new standards of compactness.

Ruggedness . . . Mallory Mercury Batteries can withstand extreme temperature and humidity, for military or severe commercial service.

A complete range of ratings and sizes is available. Write to Mallory for data, and for a consultation on your own battery requirements.

Parts distributors in all major cities stock Mallory standard components for your convenience.

Serving Industry with These Products:

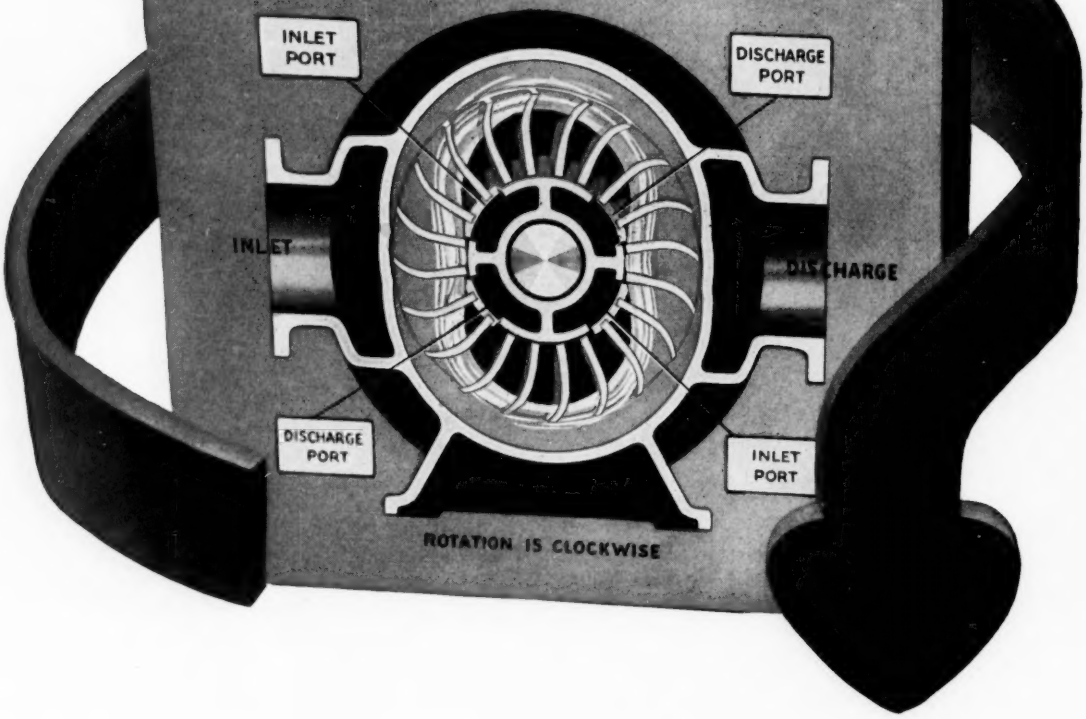
Electromechanical — Resistors • Switches • Tuning Devices • Vibrators
Electrochemical — Capacitors • Mercury and Zinc-Carbon Batteries
Metallurgical — Contacts • Special Metals • Welding Materials

Expect more . . . get more from

P.R. MALLORY & CO. Inc.
MALLORY
P. R. MALLORY & CO. Inc., INDIANAPOLIS 6, INDIANA

For more information circle **14** on inquiry card.

Nash Instrument Air Compressors deliver only clean air, free from oil or dust, and without filters



Here is Why!

You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

No oil filters.
No dust filters.
No internal lubrication to contaminate air handled.
No internal wearing parts.
No valves, pistons, or vanes.
Non-pulsating pressure.
Original performance constant over a long pump life.
Low maintenance cost.

NASH ENGINEERING COMPANY
370 WILSON, SO. NORWALK, CONN.

EDISON'S resistance temperature detectors eliminate signal amplification

MODEL 235N90-35
Designed for fast response and high resistance to the corrosive effects of rocket fuels used in guided missiles.
SPECIFICATIONS:
Stem-sensitive.
Useable temperature range —70° to +200°C.
Exponential time constant in agitated waterbath 0.8 second. Maximum hydrostatic pressure on stem: 750 psi at 100°C
Basic resistance at 0°C = 90 ohms.
Hermetically sealed.

MODEL 242P
This Detector can be operated in live steam or high temperature atmospheres up to 1300°F.
SPECIFICATIONS:
Stem-sensitive.
Useable temperature range —70° to +750°C.
Maximum hydrostatic pressure on stem: 300 psi at 750°C.
Basic resistance at 0°C = 100 ohms.
Hermetically sealed.

MODEL 230N
A general purpose Detector for temperature measurement and control in industrial processes.
SPECIFICATIONS:
Stem-sensitive.
Basic resistance at 0°C = 120 ohms.
Hermetically sealed.

MODEL 166NC
Element is concentrated in tip for sensitivity to sur face temperatures in motor bearings, etc.
SPECIFICATIONS:
Tip-sensitive.
Useable temperature range —70° to +300°C.
Basic resistance at 0°C = 120 ohms.

Thomas A. Edison
INDUSTRIES
INSTRUMENT DIVISION — WEST ORANGE, NEW JERSEY

McGRAW EDISON

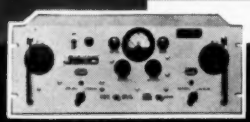
For more information circle **15** on inquiry card.

Measurement Standards

NEW
MODEL 1051
C-R-A-M
UNIT

Calibrator - Receiver - Amplifier - Mixer

The Model 1051 combines four functions. As a 10 kc to 500 mc frequency standard, it delivers sub-harmonics of a 10 mc oscillator to ±0.0005% accuracy. Discrete sine wave frequencies of 10, 50, 100, 200 kc and 1, 2, 10 mc available from rear terminals. Its 5 mc WWV receiver has a sensitivity of 5 microvolts. The amplifier and mixer sections provide a gain of several hundred times and a comparison of external signals up to 1000 mc or a comparison of external with internal signals. Price $760.



MODEL 531

MODEL 541A

MODEL 459

Crystal Impedance Meters

Four units now available to measure resonance and anti-resonance resistance of quartz crystals, including those covered by Spec. MIL-C-3098B. Capacitance, inductance and performance index (PI) of the crystal can be determined.

Model 531 (TS-683/TSM) covers range of 10-140 mcs, employing 13 calibrating resistors and an anti-resonance adapter for 10-150 ohm crystals. Price $590.

Model 541A (TS-710/TSM) for 10-1100 kc range crystals having resistances from 200 ohms to 0.5 megohms. Power dissipated in the crystal is meaured. Built-in VTVM and ohmmeter provided. Price $860.

Model 459 (TS-330/TSM) covers 1-15 mc frequency range for crystals having resonance resistances from 0 to 9900 ohms. Price $695.

Model 1207 (AN/TSM-15) covers frequency range of 75-200 mcs for 10-125 ohm crystals. Crystal voltage at series resonance is measured and power calculated. Built-in ohmmeter.

All models were developed under Signal Corps technical requirements for the national crystal testing standardization program.

Performance of all models is rigidly guaranteed. Prices are net f.o.b. Boonton, N.J. and subject to change without notice.

SEND FOR TECH. DATA

For additional information, including application data, write or phone DE 4-3100. Demonstrations available by local representatives.

RFL Radio Frequency LABORATORIES, INC.
Boonton, New Jersey, U.S.A.

For more information circle **16** on inquiry card.

Inquiries

These inquiries, representing problems facing readers of **Instruments & Automation**, are published as a free service to our readers.

Remote Water Batching and Totalizing Meters

Firm of consulting engineers seeks water meters with automatic shut-off of pumps after reaching predetermined quantity, and totalizing gallons pumped. Must be suited for city water system handling large quantities. A-225

Special Computers, d-c Amplifiers

Project engineer in systems engineering company seeks (1) a special computer to provide the time rate of change of a variable. Input signal will be from a thermocouple or strain gage (low impedance source), output of a unit will be a null-balance potentiometer. Range of time constant will be between 0.1 and 20 sec.; (2) a special computer to provide the ratio of two pressure input signals, originating from Statham transducers. Range of ratio is 0.5 to 1.1 sec.; (3) d-c amplifier to operate from low-voltage, low-impedance signal source (thermocouples, strain gages, etc.). Must be of ultra-stable classification. A-226

Servo R & D Contract

Large manufacturer of optical hardware seeks servo R&D embodying interpretation of digital signals to analog form for continuously varying rate servo control and position servo control. Work is classified. A-227

"Impactograph"

Large German electrical concern would like to identify manufacturer of "Impactograph" (an instrument that registers jolts which goods receive in transit). A-228

Do-it-yourself Kits

Professor of Medical Physics wants addresses of suppliers of build-it-yourself kits for servomechanisms, electronic work, and mechanical models. Also would like to identify a mechanical construction kit for engineers named "F.A.C.K." A-229

Rubber Grommets

Industrial supply house seeks rubber grommets (or insulators) to

dampen vibrations in mounting indicating gages on panel boards. A-230

Filter for Removal of Wood Fiber

Fiberboard manufacturing needs continuously self-cleaning filter to remove particles of wood fiber of approximately 20-micron size from air stream, without affecting moisture content of air, which is to be measured accurately. Wood fiber contains phenolic resin and petrolatum wax in small quantities. A-231

Painted Insulating Material

Research scientist in university metals lab seeks insulating material for protection of exposed electrical joints up to 3KV by painted-on one or two coats. Material must dry or cure at room temperature. A-232

High-performance Quartz Crystals

Portuguese astronomical observatory seeks two high-performance 100-kcps quartz crystals to construct quartz clocks. A-233

Floor-slip Measurement

Insurance company supervisor seeks instrument for measuring slip on floors of large office building to control within safe limits materials used in floor conditioning. A-234

Laboratory Recorders

Engineer in large chemical company seeks recorders for viscosity, refractive index, specific gravity, and acid-base titrations. Laboratory accuracy is preferred over industrial. A-235

Breaker Amplifier for Very Low d-c Signals

Atomic scientist in university chemistry department seeks breaker amplifiers for amplification of very low (10^{-7} or less volts) d-c signals from low-impedance sources. A-236

Data Reduction from Drawings to Cards or Tape

Scientist is interested in obtaining information on methods to reduce drawing data into digital form for control of machine tools from punched cards, or punched or magnetic tape. A-237

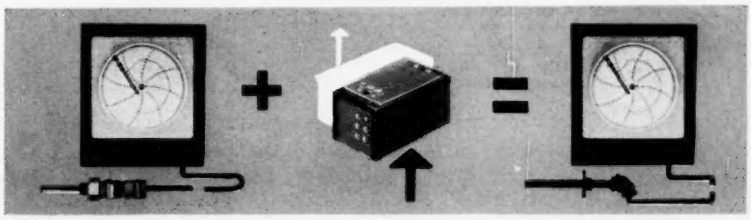
Polarograph

General manager of South-African uranium processers seeks reliable polarograph. A-238

Fully-automatic Assembling

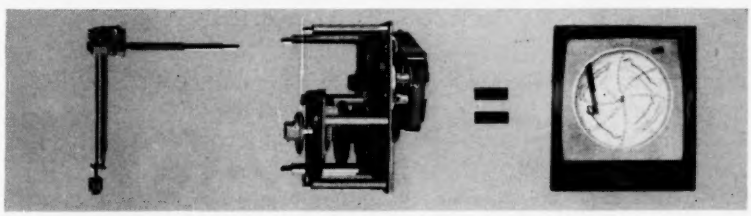
Consulting engineer in England seeks names and addresses of companies using fully-automatic assembly methods in their production. A-239

Look How the Fielden Recorder Converts into Many Instruments



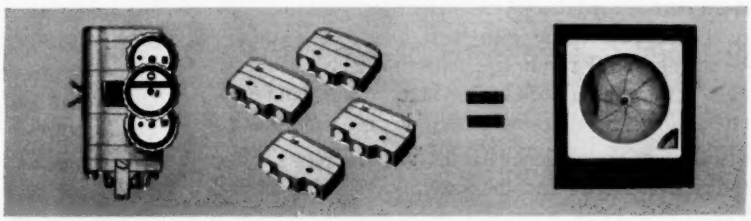
now it's a different instrument

The same Fielden Single-Point Recorder can be provided with a variety of ranges and circuits for measuring an unlimited number of process variables. By changing only the input conversion unit and rebalance elements, the Recorder can be converted to an A. C. Null Balance Circuit, a D. C. Null Balance Potentiometer, a Continuous Balance R. F. Capacitance Bridge, or a nonlinear circuit.



now it's a multi-point recorder

Without modifying the basic electro-mechanical mechanism, all Fielden Single-Point Recorders can be converted to record up to 96 points on one circular chart. Cost per point is the lowest available. All that's required is to replace the pen with a Fielden "Turret" Pen Assembly and then add a Segmental Chart Drive Unit and simple switching panel.



now it's a recording-controller

Fielden Single-Point Recorders accommodate any one of nine pneumatic control units. Add a unit, and the recorder becomes a pneumatic on-off controller or a pneumatic proportional controller with any combination of proportional, reset and rate actions. Just as simply, up to 4 SPDT switches can be added for a wide variety of electric control actions.

The "building block" approach to instrumentation is only one of many advantages Fielden instruments now bring to the indicating, recording, controlling, monitoring or scanning of practically every measurable variable. Along with its ever-growing variety of instruments, Fielden also offers a full line of sensing elements, accessories and supplies.

SEND FOR LITERATURE

Mr. Controls®

Robertshaw-Fulton CONTROLS COMPANY

FIELDEN INSTRUMENT DIVISION

Dept. A, 2920 N. 4th St., Philadelphia 33, Pa.

For more information circle **17** on inquiry card.

Bill Waddell discusses ANALOG/DIGITAL CONVERSION

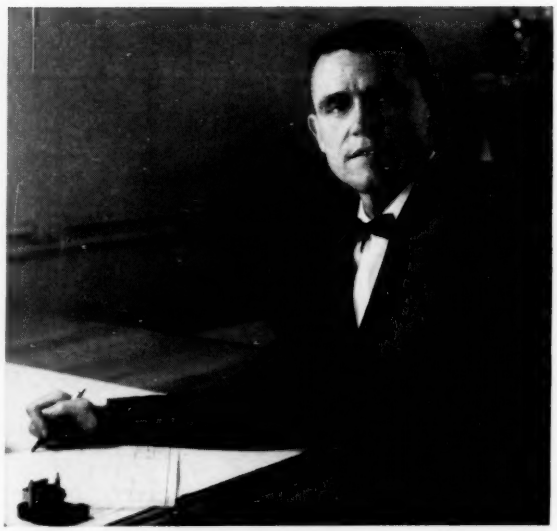
For the past few years one of the most serious concerns in systems design has been the development of equipment eminently suited to "link" the analog input to the digitized output assemblies of the system. Examples of such links are to be found in radar recording problems in the missile test field, in the control of machine tool operations and, most recently, in data logging in the petrochemical and chemical processing industries. In these and similar instances, there has been a conscious striving to produce highly specialized pieces of conversion equipment in an attempt to adapt the system to the particular control problem at hand.

This striving has also led to increasingly frequent discussions of analog to digital conversion in engineering circles. Such discussions have stimulated interest in, and have actually succeeded in clarifying, basic problems faced by the engineer in producing units suitable for the digitization of specific function variables.

However, contending for attention along with the requirement for restricted-purpose conversion equipment, are the types of analog functions requiring to be digitized. These have continuously increased in numbers, in complexity, and in the imposition of increasingly severe criteria for reliability. To illustrate, systems today are successfully coping with shaft rotations, linear displacements and the complete gamut of electrical signals. A few systems have been built where pressure, temperature, and flow variables have been directly converted.

In the past the tendency has been to design the analog to digital converter and then assemble systems around the converter block. Examples of this approach are to be found in the handling of high-speed serial binary digits from input voltages, and in shaft converters containing cyclic codes requiring complicated translations before the outputs are readily adaptable for further processing. In order to achieve suitable solutions in such cases, it became necessary to introduce auxiliary equipment which frequently turned out to be much less reliable than the digitizer. This led, therefore, to more highly complicated and costly systems rather than significantly simplifying the basic analog to digital converter.

The current approach is to engineer a "link" integrating the components directly into the system. Only in this manner can they be properly weighted to assume their true and economical function. This has resulted in consciously avoiding marrying, for instance, a 5,000 sample per second analog input to a converter capable of spewing out 50,000 samples per second. Or by the same token, feeding 50,000 samples per second into subsequent processing components not adequately provided with control equipment and/or direct methods for recording such rapid outputs.



Bill Waddell, systems input-output specialist, discusses analog to digital conversion.

The present awareness of the problem, however, makes for a most encouraging outlook in the foreseeable future. Design break-throughs are bound to integrate the analog to digital conversion step into its proper and logical relationship to the total system. Systems will then become less complex and significantly more reliable, which undoubtedly will rapidly result in unfolding important new fields suitable for control applications.

By applying the latest proven techniques, our well-qualified staff at Daystrom Systems is prepared to take single responsibility of assembling and installing a system to meet your needs. We are currently compiling a file of new applications and papers on various parts of systems, both industrial and military. If you are interested in receiving the file and periodic additions, please write us.

DAYSTROM SYSTEMS
Division of Daystrom, Inc., 5640 La Jolla Boulevard
La Jolla, California Telephone GLencourt 4-0421

For more information circle **18** on inquiry card.

INQUIRIES—CONTINUED

Electronic Devices in Automation

Electronics senior at Belgian university seeks catalogs from manufacturers of electronic devices used in automation. A-240

Tank Level Indicator

German manometer and thermometer firm wishes to identify American manufacturer of "Gallo" remote-reading oil tank meter, sold in Germany by Swedish concern. A-241

Spring-wound Clock Movement

Manufacturer seeks spring-wound lever-escapement 10-day movement for time recorder. Must fit space 3" x 2⅝", 1¾" high. Repeat orders assured. A-242

Oxygen, Ammonia Analyzers; Magnetic-susceptibility Thermometers

Instrument engineer in India seeks manufacturer of magnetic-susceptibility thermometer. Requests also literature on oxygen and ammonia analyzers. A-243

Market Place

Manufacturing Licenses Sought

British electronics instrument manufacturer would like to obtain manufacturing licenses for (1) special electronic instruments, (2) electronic inspection devices, (3) oscilloscopes, (4) electronic test instruments, (5) pulse generators, (6) phase measuring equipment, (7) thickness testers, or similar equipment, Write the Market Place, c/o Instruments Publishing Company, 845 Ridge Ave., Pittsburgh 12, Pa.

French Representation

Manufacturers' representative in France, now handling large French, American and German lines of measurement and control instruments, binoculars, microscopes, thermocolorimeters, professional lenses, photometers, etc., and with outlets in all parts of France, desires to represent other American firms; seeks contact with American manufacturers of industrial, scientific and optical instruments who want French representation. Write the Market Place, c/o Instruments Publishing Company, 845 Ridge Ave., Pittsburgh 12, Pa.

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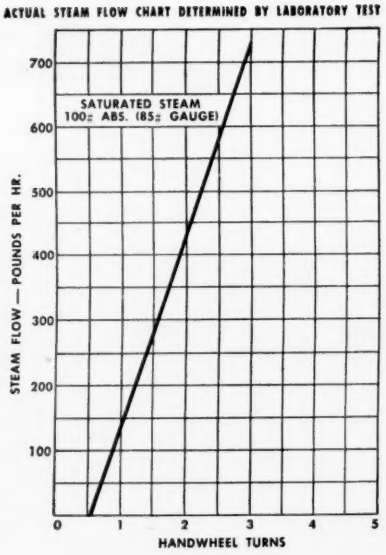


HANCOCK "Flocontrol®" VALVES

- ✓ **Insure Uniform Quality Through Closer Control**
- ✓ **Save Steam and Fuel on Process Work**
- ✓ **Save Money by Cutting Maintenance**

Hancock "Flocontrol" Valves provide a 3-in-1 design that combines variable orifice, shut-off and index. The valve opening can be set to within one-tenth of a turn of the handwheel. The micrometer dial and pointer make it easy to duplicate any desired setting instantly.

Each valve has a scientifically designed V-port valve disc that insures proportional flow throughout the entire lift of the stem. Straight line flow with separate shut-off seating surface removed from the controlling V-ports eliminates the need for a separate shut-off valve.

Hancock "Flocontrol" Valves are available in Bronze and Steel to meet specific requirements. All are rugged valves, designed and constructed to provide the *economy of quality* so essential to assure top performance in the most demanding services.

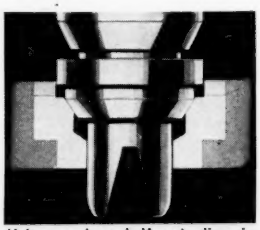
Hancock Bronze "Flocontrol" Valves. *Types:* Globe and Angle. *Sizes:* ¼" through 2". *Connections:* Screwed Ends. "500 Brinell" Stainless Steel Seats and Discs. 150# Series for all pressures up to 150 psi at 358° F. 300# Series for all pressures up to 300 psi at 550° F.

Hancock Forged Steel "Flocontrol" Valves. *Types:* Globe and Angle. Renewable Hard-Faced Stainless Steel Seats. "500 Brinell" Stainless Steel Discs. *Connections:* Screwed, Socket Weld and Flanged Ends. *Sizes:* Screwed and Socket Weld Valves—¼" through 2". Flanged Valves—½" through 2". *Screwed and Socket Weld Valves:* For all pressures up to 600 psi at 910° F. O.W.G.—2000 psi at 100° F. *Flanged Valves:* For all pressures up to 600 psi at 850° F. O.W.G.—1440 psi at 100° F.

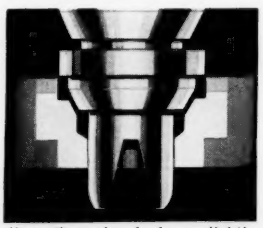
Hancock Cast Steel "Flocontrol" Valves. Globe Type with Screwed Bonnet. Renewable Stainless Steel Plug Seats and Discs. *Sizes:* 2½" and 3". *Connections:* Screwed and Flanged Ends. For all pressures up to 395 psi at 775° F. O.W.G. —720 psi at 100° F.

Hancock Cast Steel "Flocontrol" Valves. Globe type with Bolted Bonnet. Renewable Stainless Steel Plug Seats and Discs. *Sizes:* 2½", 3" and 4". *Connections:* Flanged Ends. 300# Series for all pressures up to 395 psi at 775° F. O.W.G.—720 psi at 100°F. 600# Series for all pressures up to 800 psi at 775° F. O.W.G.—1440 psi at 100° F.

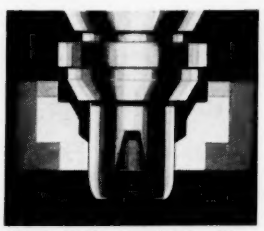
HANCOCK "FLOCONTROL" VALVES OPERATE LIKE THIS . . .



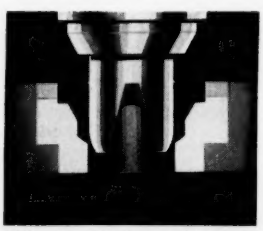
Valve seat and V-port disc in fully closed position. Pressure pushes upward under the disc. Note that the shut-off seating surface is completely removed and separate from the flow-controlling V-ports.



Here the valve is in a slightly opened position. The V-port disc is permitting a measured flow of the media.



This is the intermediate position. Note that the V-port disc now permits a proportionally greater flow of the media.



Fully opened valve provides maximum flow. The special micrometer dial and pointer permit any open position to be duplicated accurately.

YOUR INDUSTRIAL SUPPLY DISTRIBUTOR is as close as your telephone. Let him help you select the right Hancock "Flocontrol" Valves for your needs. You can depend on him for fast delivery from local stocks.

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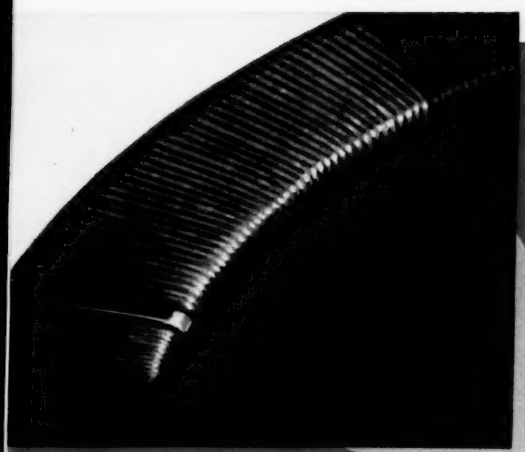
HANCOCK VALVES

A product of **MANNING, MAXWELL & MOORE, INC.** Watertown 72, Massachusetts

MAKERS OF 'ASHCROFT' GAUGES, 'AMERICAN' INDUSTRIAL INSTRUMENTS, 'CONSOLIDATED' SAFETY AND RELIEF VALVES, 'AMERICAN-MICROSEN' INDUSTRIAL ELECTRONIC INSTRUMENTS, *Stratford, Conn.* 'HANCOCK' VALVES, *Watertown, Mass.* 'CONSOLIDATED' SAFETY RELIEF VALVES, *Tulsa, Oklahoma.* AIRCRAFT CONTROL PRODUCTS, *Danbury, Conn. and Inglewood, Calif.* "SHAW-BOX" and 'LOAD LIFTER' CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES, *Muskegon, Mich.*

For more information circle **20** on inquiry card.

OHMITE® RHEOSTATS HAVE *Smoother Windings!*

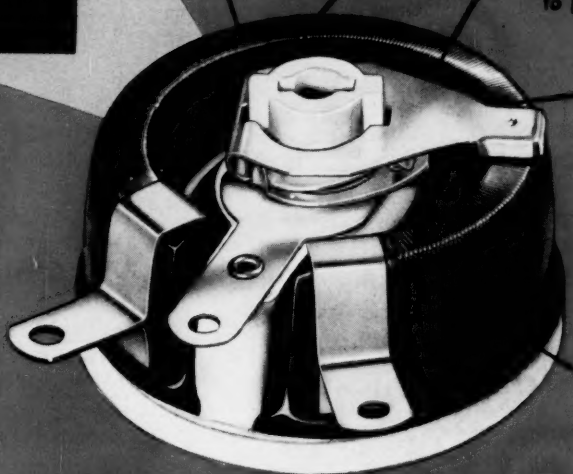


5 REASONS WHY—

1. PRECISION GROUND CORE . . . Cores for fine wire, high resistance units are ground to give a smooth, flat contour for the contact brush.

2. SMOOTH JUNCTIONS where wire sizes change between sections of tapered windings . . . less differential between wire sizes.

3. PERMANENTLY LOCKED WINDINGS . . . Core and windings are bonded together with vitreous enamel to prevent shifting of wire.



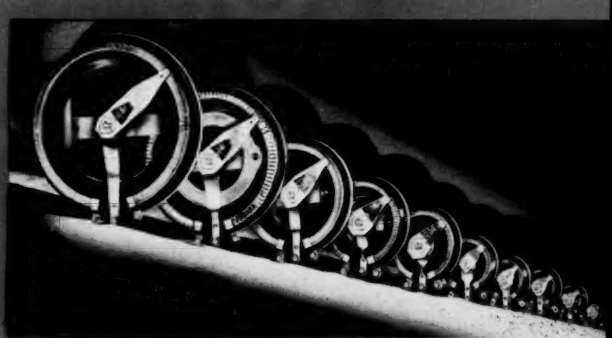
4. UNIFORM WIRE SPACING . . . Ohmite has developed special winding machines to insure uniform spacing and eliminate crossover of adjacent turns on fine wire units.

5. FLUSH TERMINALS . . . Terminals are flush with windings . . . brush glides smoothly from windings to terminal.

See for yourself! Examine an Ohmite Rheostat first hand. Compare its smoother resistance windings. Turn the knob and note how easily and smoothly the contact brush glides over the rheostat windings.

There's less wear on the resistance wire and on the contact brush. The brush makes contact with all of the turns and the resistance varies smoothly and uniformly as the shaft is turned. Every Ohmite Rheostat is *individually tested* on ultrasensitive electronic instruments to assure perfect contact between the winding and the contact brush.

Standardize on Ohmite Rheostats for unsurpassed dependability, smoothness of operation, and long life.



A COMPLETE LINE OF RHEOSTATS

from 25 to 1000 watts. Also available to meet MIL-R-22A requirements in each of the 26 type designations.

Write on company letterhead for Catalog and Engineering Manual No. 40.

Be Right with **OHMITE®**

OHMITE MANUFACTURING COMPANY, 3615 Howard Street, Skokie, Illinois (Suburb of Chicago)

RHEOSTATS • RESISTORS • RELAYS • TAP SWITCHES

For more information circle 25 on inquiry card.

LEWIS SELECTOR SWITCHES
FOR RESISTANCE THERMOMETERS AND THERMOCOUPLE THERMOMETERS

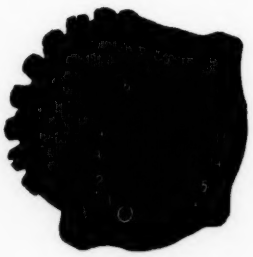
EACH SWITCH HAS "OFF" POSITION PLUS NUMBER OF POINTS LISTED.

Switch Part Numbers

Points	Size	Thermocouple Type	3 Wire Resistance-Thermometer Type
2	2″	11S2	36SR2
3	2″	11S3	36SR3
4	2″	11S4	36SR4
5	3″	10S5	37SR5
6	3″	10S6	37SR6
8	3″	10S8	37SR8
9	3″	10S9	37SR9
10	3″	10S10	37SR10
12	3″	10S12	37SR12
16	3″	10S16	37SR16
18	3″	10S18	37SR18
20	3″	10S20	37SR20
24	4″	27S24B2	38SR24
28	4″	27S28B4	38SR28
40	4″	38S2C	

(No. 38S2C is made with soldering-lug terminals)

2" SIZE



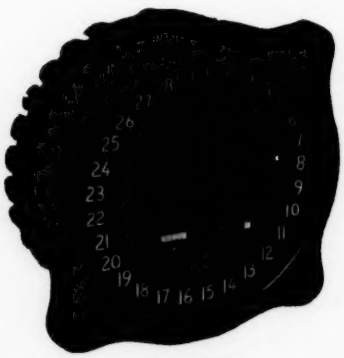
3" SIZE

SPECIAL SWITCHES

No. 37S6C2, Four "4 Point and OFF" thermocouple switches combined in one 3″ case.

No. 9S5, Single Pole, Four Point Instrument Switch in 1¼″ round case.

No. 44S4, Six Pole, Double-throw Instrument Switch in 2½″ round case, one hole mounting, ½-32 threaded bushing.



4" SIZE

DESIGNED FOR TEST WORK AS WELL AS FOR PERMANENT INSTALLATIONS. LEWIS SELECTOR SWITCHES ARE CONSTRUCTED WITH STURDY CONTACTS OF LOW RESISTANCE AND POSITIVE DETENT. THESE SWITCHES ARE SPLASHPROOF, DUSTPROOF AND ARE BUILT TO GIVE YEARS OF SERVICE.

THE LEWIS ENGINEERING CO.
Specialists in Electrical Temperature Measurements
NAUGATUCK, CONNECTICUT

For more information circle **22** on inquiry card.

INSTRUMENTS and AUTOMATION Trends

Industrial market for magnetic amplifiers is expected to reach $100 million by 1957, with 50% industrial sales. About 150 producers are in this field; mostly "small."

Industrial research has grown from $400 million in 1930 to $6 billion annually says E. Reeves, Esso Research, and is growing at rate of 12% per year. More than 500,000 persons are now engaged in industrial research. But—see next item.

Published statistics on "research expenditures" are unreliable, says recent report "Research and Development in the Corporation" (by Amer. Inst. of Mgt.). Recent figures give $1.7 billion as government and non-profit research expenditures, and $3.7 billion as private industry expenditures. However, $1.4 billion of the $3.7 billion was financed by federal government. Also, popularity of word research is causing public-relations-minded management to call many appropriations for engineering and production by the word research; modifications of unsatisfactory equipment are being called research; conventional engineering work is now being called applied research; capital expenditures for research equipment, which should be amortized, is often thrown in with the annual list of research expenditures. Result: Management makes stockholders feel that company is progressive; annual research statistics for industry are swollen beyond true value. Truth is that total of private research conducted annually by private industry is trifling in proportion to gross national product; U.S. occupies a low ranking among industrial nations whose private corporations engage in research.

National Science Foundation reports that university R&D was $285 million in 1954—about 5% of total R&D of $5.4 billion. Importance of this is that this is mostly basic research. Of $285 million total, $281 million was spent by 190 engineering and science colleges. Liberal arts and teacher colleges spent only $4 million on research.

NSF reports that in 1953-54 school year, 74 of existing 80 medical schools spent $63.3 million for medical research.

Trend in trends: Note difference between the billions spent for industrial and military R&D and the few millions spent on basic research or R&D in the life sciences and humanities. The trend here is dangerous to all of humanity.

Panhandle Pete

The Rampant Ramp

FRIENDS, are you aware of the astonishing changes made in the Engineering profession in recent years? Do you read the advertisements for engineering talent in the trade magazines? And have you seen the recent advertisement in one of the magazines which is aimed at the engineer's wife? This ad shows a cute little cottage somewhere up in the mountains out West with a woman (Engineer's wife) leaning on a tree, looking at this garden of Eden and saying to herself, "Ugh! I hate mountains."

Whoever wrote this ad is assuming that engineer's wives are living in slums and therefore "All we have to do is get her out here in this mountain scene and her faithful husband will follow right along and since he is an engineer, bless his little heart, maybe he will come and work for us and help us develop our Pog Fockets." Isn't this a sneaky way to hire an engineer? In addition to this, the engineer is being wooed with offers of hunting, fishing, camping, boating, grand-opera, bingo, bear-baiting —even money.

While reading in the April issue of *I&A* the story of *Science on TV*, especially the paragraph about Progress on Rockets being in such demand—say, did you see the girls Dr. Klein manages to work with? Diane Weber here and some other blond in the February story. No wonder everybody is interested in computers and rockets.

The Wallace Electronic Service Company, J. L. Bus Wallace, Chief Engineer, about which I write quite often, has a Rocket Engineer. Yes they do! The name of this fellow is Elmer Flannelgurdle, B.S.R.D.—Rocket Designer. Elmer has been interested in rockets since the time, when he was five years old, he threw a match into a fireworks display in the window of McGonigals' Hardware and Grocery store down at the county seat and managed to burn down half the town.

Elmer completed his schooling and spent many years working for the government—K.P. duty in the Spanish American war and two world wars—and only recently was hired by Wesco!. (If the truth be known, Elmer married Penelope Klapsaddle, sister to the genial Sales Manager of Wesco!) Waldo I Klapsaddle, Jr, who was the featured "D.R." of the month in the November *I&A*, seeing more of the man's ability than meets the eye (Elmer lost most of his fingers, two toes, one ear and all of his hair on that memorable 4th of July) hired him right after the ceremony. "After all, Cuz, I couldn't support the bum the rest of his life," says Waldo, "Besides, you ought to see his wife. It's worth something, Cuz, getting her off my back."

What I'm getting around to is that several months ago an engineering Talent Scout came through this part of the country and, hearing that Wesco! had an unhappy Rocket Designer on the payroll, came down to interview Elmer. He offered Elmer all that good fishing, but my oh my, it seems Elmer doesn't like fish—"Ah don't know how anybody can catch or eat those slippery, slimy stinking fish!"

Then he offered Elmer a lot of good hunting, but Elmer doesn't hunt or eat meat—"When Ah takes time to think about eating meat, especially big, thick, juicy steaks, I am ashamed to look into the big, soft, brown eyes of a peaceful cow." He also offered Elmer's wife a mountain, but she can't stand altitude so living in the mountains is out—"Gosh, I git sick jist going upstairs and besides I can't help spittin' of'en high places when I gits on 'em." And Elmer is allergic to salt air and that is that.

But the real clincher for staying home was the lack of ramps in the Western U.S.A. "Ah didn't mind the other things too much, but doggone it, Ah just have to have my ramps come Spring."

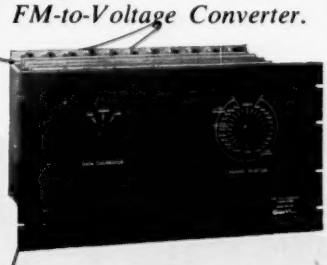
Ramps? You never heard of ramps? My gosh, ramp-eating is a time-honored West Virginia custom. We go out there in the mountains around Elkins and visit a friend of ours, Stanley Fredlock, and we eat ramps, ramp salad, baked ramp, ham and ramp and stewed ramps. Ramps are sorta like a cross between wild onions and garlic. The aroma of fresh-peeled ramps will corrode brass at fifty feet. Eating ramps is supposed to be beneficial to the health, soothing to the stomach, comforting to the bowels, as well as endowing strength and vitality. Some out-of-state tourist staying the night at Buckhannon went home with the impression that the smell of the ramp, either stewed or raw, will asphyxiate small animals at twenty paces and humans at ten. Can it be that the gawd-awful smog in California is caused by some West Virginia ramps that were carried to California by one of the thousands of engineers that have been seduced Westward? This is an obvious possibility.

As it so happens, Dr. Alles, our Director of Research, has already applied his talent to this oderous problem. "After all, old chap, it is a well-known fact that the ozone level rises in the atmosphere in proportion to the contamination, following the Law of J. Pulaski dealing with Concentrated Concentrates. Since O_3 is a very potent homocidal agent, it is obvious to me that old mother nature is trying to kill something—probably a colony of W. Virginian ramp-eaters—in Los Angeles. So all we have to do is give her a little help and convert California's useless earthquakes into useful electricity via my portable pizzicato piezo-electric pizza generators and produce sufficient ozone according to the equation $\Sigma X_o \Delta t + \int X_n \Delta t$—and thus neutralize the smog." We'll keep you informed on what happens. We have a full team at work on this vital problem.

Panhandle Pete

NEW! ultra-stable FM Telemetering Discriminator*

**Epsco Model FM-108 FM-to-Voltage Converter.*

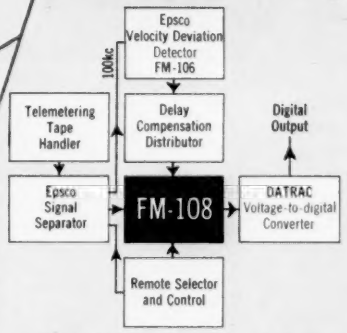


EPSCO'S MODEL FM-108 crystal-controlled ultra-stable, all-channel discriminator presents a new *standard of accuracy* . . . better than an order of magnitude more accurate and stable than any other commercially available equipment . . . and with absolutely *no* adjustments! This new standard of FM data processing features:

- **HIGH DYNAMIC ACCURACY:** Absolute accuracy is better than 0.05%, and the dynamic accuracy of the equipment from input to associated band-pass filter through the low-pass output filter is better than 0.2%.
- **LONG-TERM STABILITY:** 0.2% for life of equipment with no adjustments for zero drift, gain and line voltage variations, etc.
- **VERSATILITY:** Converter operates on any of 23 standard IRTWG telemetering sub-carrier frequencies from 400 cps to 70kc. Band switching may be accomplished remotely or by selector switch on front panel.
- **AUTOMATIC WOW and FLUTTER COMPENSATION:** With Epsco FM-106 Velocity Deviation Detector and Epsco CD-601 Velocity Deviation Compensation Distributor, errors from tape speed variations are reduced by a minimum of 35 db.
- **ZERO and 100% DATA CORRECTION:** Produces automatic compensation for variation of transmitting sub-carrier oscillator frequency and gain by a transistorized electro-mechanical servo feature.
- **DYNAMICALLY ACCURATE SELECTABLE LOW-PASS FILTERS:** A 5-pole filter utilizing precision wire-wound resistors and ultra-stable polystyrene capacitors in combination with chopper-stabilized d-c amplifiers provides:
  - Phase linearity deviation not exceeding 0.25 degrees over 90% of bandwidth.
  - Pass band flat within ±0.1% (0.01db) to F_c.
  - Minimum attenuation of 54 db of nearest beat frequency between sub-carrier channels.
  - A total of 62 different low-pass filter bandwidths selectable from 11 cps to 3490 cps.
- **PHYSICAL CHARACTERISTICS**

  SIZE: 10½" of space of standard 19" cabinet.
  WEIGHT: 29½ pounds.
  CONSTRUCTION: Constructed of 8 separate plug-in chassis assemblies containing electronic and magnetic components. All components are accessible on the standard layout forms.

Engineering data sheet available on request.



Epsco Model BF-601 Signal Separator units, each of which contains 23 band-pass filters, are available for separating the composite sub-carrier signal prior to input to FM Converter.

Complete FM telemetering receiving stations are available with or without wow and flutter compensation and zero and 100 percent correction features. Also available is the Epsco Model VCO-718 All-Channel Voltage-Controlled Oscillator for FM Discriminator calibration . . . which occupies only 3½ inches of panel space including power supply.

In the West, contact:
Epsco Service Corporation of California
1722 Westwood Boulevard
Los Angeles 24, California

Epsco *incorporated*

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INSTRUMENTS and AUTOMATION News

Principles & Applications 1036 to 1053
Stock Report 1053
New Plants & Mergers 1057
People in the News 1063

SAMA's Thirty-ninth Annual Meeting

WHITE SULPHUR SPRINGS, W. VA.—The yearly meeting of The Scientific Apparatus Makers Association (SAMA), was held April 28 to May 2, 1957 at the Greenbrier, White Sulphur Springs, W. Va. More than 400 members and guests attended. (President H. F. Dever's address is published on pages 1081-1084.)

The new president for 1957/58 is R. E. Welch, vice president and treasurer of W. M. Welch Mfg. Co., who succeeds retiring president Henry F. Dever, president of Brown Instruments Div., Minneapolis-Honeywell. Mr. Welch, who was president-pro tem, is succeeded by Dr. G. A. Downsbrough, president of Boonton Radio Corp.

The group picture shows the new officers, directors, and section chairmen.

OFFICERS, DIRECTORS, AND SECTION CHAIRMEN l. to r.: Erik L. Sjostrom, president, John E. Sjostrom Co.; Edward J. Albert, president, Thwing-Albert Instr. Co.; Earl R. Mellen, president, Weston Electrical Instr. Corp.; E. J. Rhein, sales manager, scientific div., Kimble Glass Co.; T. M. Mints, president, E. H. Sargent & Co. (treasurer); Henry F. Dever, president, Brown Instruments Div., Minneapolis-Honeywell Regulator Co.; Ray G. Halvorsen, executive vice president, Hamilton Mfg. Co.; Richard E. Welch, vice president & treasurer, W. M. Welch Mfg. Co. (president); R. E. Olson, president, Taylor Instrument Cos.; A. G. Dixon, president, International Equipment Co.; L. W. Higgins, assistant to the president, The Gaertner Scientific Corp.; Louis L. Vayda, president, Bacharach Industrial Instrument Co.; and Dr. G. A. Downsbrough, president, Boonton Radio Corp. (president-pro tem).

New Retma Standards

NEW YORK, N. Y.—New recommended standards have been released:

RS-180—Power Transformers for Electronic Equipment (This Standard, from Standards Proposal No. 510, is a revision of TR-102-B).

RS-186—Standard Test Methods for Electronic Equipment (This Standard, from Standard Proposal Nos. 467 and 497, is new material).

International Conference on Cybernetics Scheduled for 4th Automation Exposition, New York, June 1958

PITTSBURGH, PA.—During the recent visit of Dr. Georges R. Boulanger, President of the Association Internationale de Cybernétique, to the United States, plans were made for a Conference on Cybernetics at the Fourth International Automation Congress and Exposition, June, 1958. Dr. Boulanger will arrange for an international panel of scientists as speakers.

Dr. Boulanger is also on the faculties of the Polytechnic Institute of Mons and the University of Brussels.

During the First International Congress on Cybernetics, in Namur, Belgium, June 26-29, 1956, the formation of the Association Internationale de Cybernétique was announced. The aims of the Association are to forge a permanent link between scientists in various countries whose work is associated with cybernetics. The Association is publishing the proceedings of the First International Cybernetics Congress and will edit an International Cybernetics Review. Membership is open to all individuals active in this field. This annual membership dues are 200 Belgian francs ($4.00). Application for membership can be made to Association Internationale de Cybernétique, 13 rue Basse-Marcelle, Namur, Belgium, or membership blanks can be obtained from the Fourth International Automation Exposition, 845 Ridge Ave., Pittsburgh, Pa.

Gulf Oil Corporation opens Three New Research Labs

PITTSBURGH, PA.—The forty-four-building Gulf Oil Research Center at nearby Harmarville, which started operation in 1935, has been enlarged by the addition of 3 new multi-million dollar laboratories recently opened in a splendid ceremony. Keynote speaker was Gen. Matthew B. Ridgway, World War II hero, who is presently chairman of the board of trustees of Mellon Institute of Industrial Research, Pittsburgh.

The three fully instrumented new structures are (1) The William Larimer Mellon Production Research Lab for research on new drilling and oil production methods, (2) the Richard Beatty Mellon Automotive Products Lab for research on fuel and lubricant testing, and (3) the Andrew William Mellon Nuclear science lab for research on nuclear energy applications to all phases of petroleum science.

In the Automotive Products Lab 20 engine test cells house a variety of engines (including a powerful gas turbine delivering 240 hp at 36,000 rpm, and diesel engines) in which experimental products are evaluated

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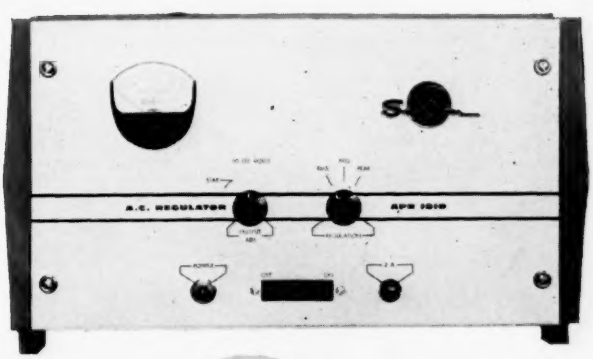

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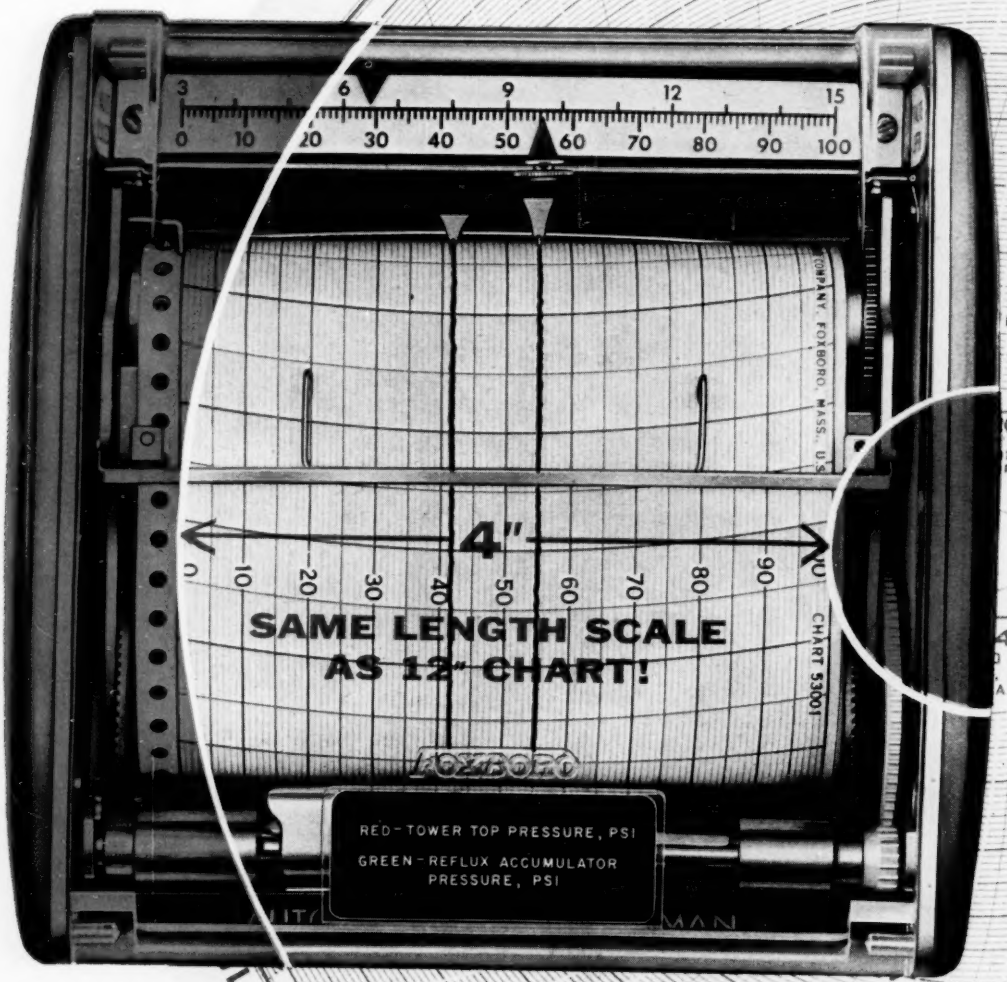
CONTROL STATION



ACTUAL SIZE illustration of Consotrol Instrument super-imposed on standard 12-inch chart. Note full 4" wide strip chart has same length scale as 12" circular chart.

CONSOTROL INSTRUMENTS

RECORDING · CONTROLLING · INDICATING

CONSOTROL* RECORDING

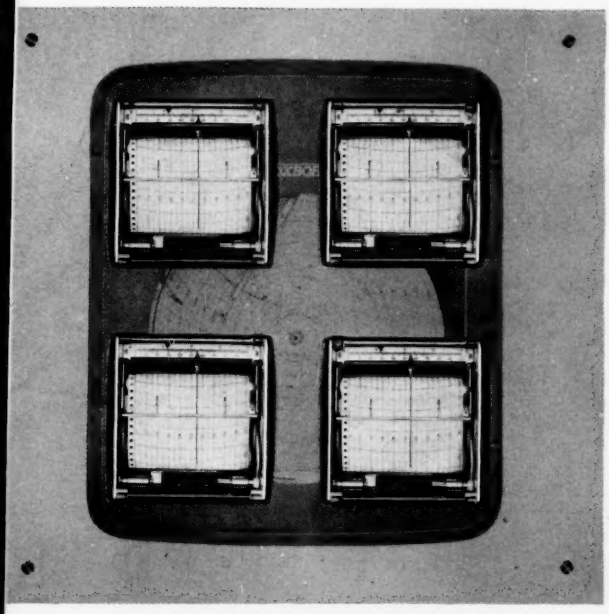


Illustration shows how 4 Consotrol Instruments require less panel space than does a single, conventional 12" recorder.

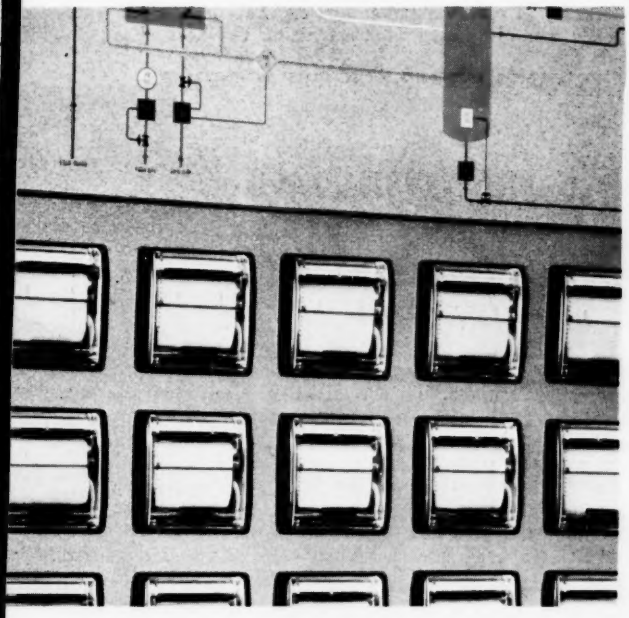
The ORIGINAL small-case control panel instrument with a FULL SCALE 4 INCH CHART...

Full-scale *readability!* Here is the industry standard set by Consotrol Instruments, with no compromise in compactness, convenience, or performance.

These Recorders and Recording Control Stations are so compact you can actually mount 4 in the space required by 1 standard 12-inch recorder. And yet, inside the case, all components are full size — nothing is "miniature."

With the integrally mounted Model 58 Controller, the Foxboro Consotrol Recording Control Station provides precise, dependable control and full-scale chart records in one-quarter the panel space. Maintenance is easier too, with all calibration adjustments made from the front . . . re-inking needed only twice a year . . . chart changes as seldom as once a month.

For the complete story, write for Bulletin 13-18. **The Foxboro Company, 466 Norfolk St., Foxboro, Massachusetts, U.S.A.**



Typical control panel showing Consotrol Recording Control Stations. Associated M/58 Controllers, integrally mounted, pull out with the recorders.

INTRODUCED IN 1952 – OVER 25,000 NOW IN USE

*Reg. U.S. Pat. Off.

FOXBORO

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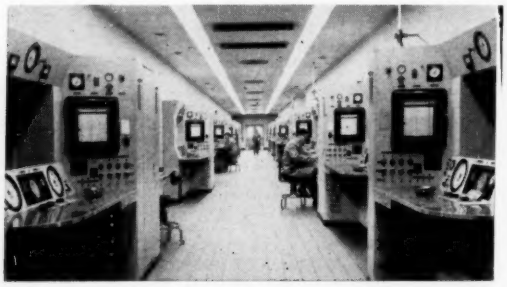
under severe test conditions. In an extra king-size cell —the 10,000-cu-ft chassis dynamometer cold room— vehicles including the biggest "Scenicruiser" can be tested in environments ranging from 100°F and high humidity to —70°F. Brown recorders and precision indicators are used extensively for temperature measurement and control. The picture shows the corridor in which the console-type panels bearing all instruments can be seen. Conspicuous are 12-point L&N Speedomax recorders, and pressure gages supplied by Wallace & Tiernan.

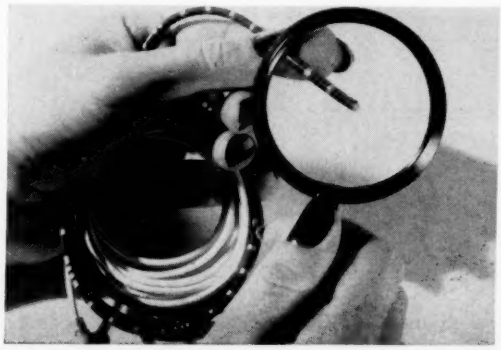


In the Nuclear Science Lab a 3-million-volt Van de Graaff particle accelerator furnished by High Voltage Engineering Corp., has been installed. Streams of charged particles (electrons, protons) and uncharged radiation (neutrons and penetrating x-rays) can be produced to study effects on catalysts, oil recovery techniques, etc.

Gulf builds a great number of highly-specialized instruments in its own shops. The Airborne Magnetometer is a development of Gulf, as is a new Batch Interface Detector, which uses a dielectric-constant probe as the primary element to record when the product flowing through the pipeline (used as a common carrier) starts and ends. Other new significant developments that have originated from the Research Center are the Fisher-Gulf Partition Gas Chromatograph, and an Arsenic Detector which indicates the presence of minute quantities of 1 to 5 parts per billion arsenic in a petroleum distillate.

Instrumentation of the Heart

PITTSBURGH, PA.—The heart, the prototype of a pump, is getting its instrumentation and mechanical spare parts. Two stories have recently reached our desk: A tiny microphone, passed through an artery or vein directly into any part of the heart, will soon transmit sounds to the listening physician, which will help him locate a trouble spot. Made by Gulton Industries the ultra-sensitive pickup, measuring only 1/20″ in dia, and ¾″ in length, was experimentally used on a dog, and transmitted converted heart sounds to an oscilloscope.



Likewise a minute diaphragm located in the tip of the catheter transmitted blood pressure, and an electrocardiograph rounded out the triple oscilloscopic picture of heart sound, blood pressure, and electrical impulses generated by the heart.—Repair of a mitral valve of a 34-year old woman, by placing a spring into the heart, was reported from Wayne University Medical School. The material used is Elgiloy, developed by Elgin National Watch Co. for mainsprings. The woman is doing fine . . .

Claire Duane Finnell

The staff of *Instruments & Automation* is grieved to hear of the untimely death, at age 33, of Claire (Chuck) Finnell, sales manager for Analog Computers, Berkeley Division of Beckman Instruments, Inc., who died June 3, 1957. The analog computer field, the instrument industry, and the nation itself has lost a useful and good citizen, a young man of high principle who had already made basic contributions to needed technology. A memorial fund under the chairmanship of Joseph L. Hussey, Computer Manager at Berkeley Division of Beckman Instruments, Inc., has been set up in his name. Proceeds will go to the American Cancer Society.

Electrodynamic Standards for Vibration Pickups

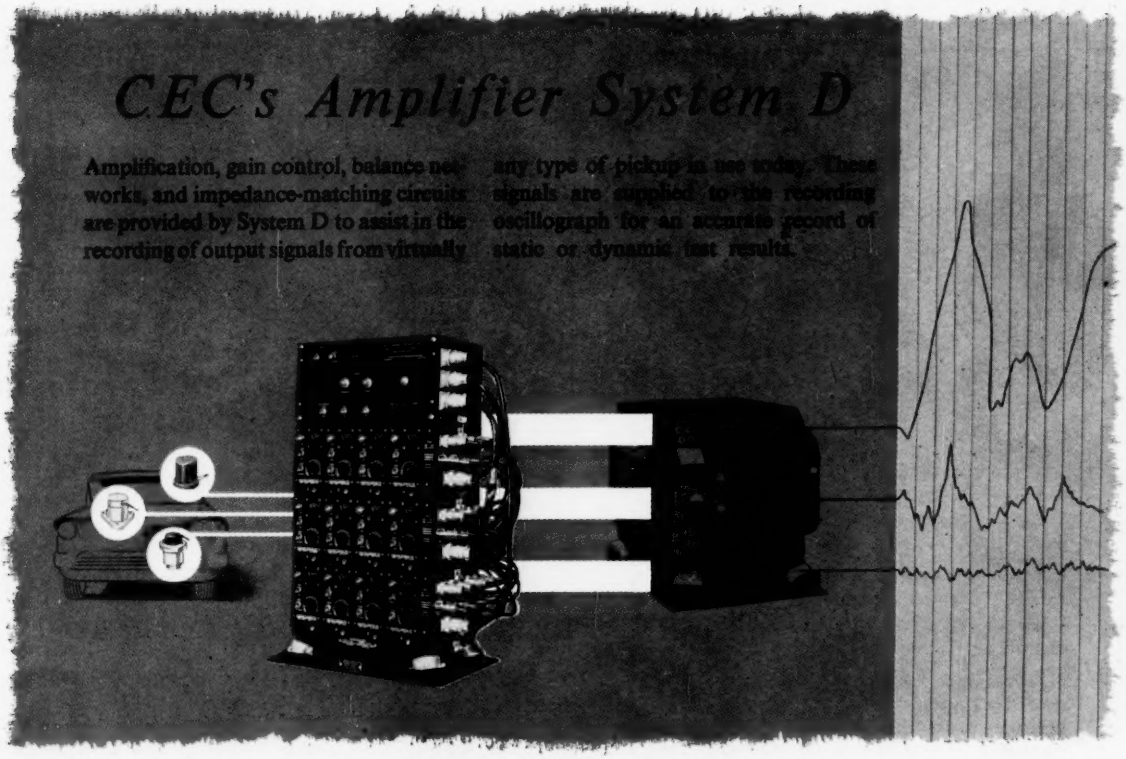
WASHINGTON, D.C.— The successful performance of the thousands of vibration pickups now in use by government and industry for testing purposes, depend on the accuracy of observations and of calibration. The National Bureau of Standards, recognizing the need, has

developed a method for standardizing electrodynamic calibrators. The calibrator used has three basic components (and principal moving parts)—driving coil, mounting table and velocity-sensing coil. It is standardized by determining the relationship between its electrical output and the vibratory motion. All direct measurement of the vibratory motion itself is avoided.

Tire Operating Temperatures

WASHINGTON, D.C.—The National Bureau of Standards has developed a precise, direct method for determining tire operating temperatures. Power loss causes

Eight years of proven stability and reliability


CEC's Amplifier System D
Amplification, gain control, balance networks, and impedance-matching circuits are provided by System D to assist in the recording of output signals from virtually any type of pickup in use today. These signals are supplied to the recording oscillograph for an accurate record of static or dynamic test results.

Amplification for multichannel recording

Companies who purchased Consolidated's System D when it was first introduced eight years ago report that these same amplifier systems are still giving consistently stable, high-precision performance in steady use. Maintenance costs have been negligible.

Rugged, lightweight construction and ability to perform over a wide range of temperatures make Amplifier System D ideal for laboratory, field, and flight-test applications. A typical System D consists of any combination of linear/integrating amplifiers and/or carrier amplifiers up to a maximum of 12 channels, a combination oscillator/power supply, and a shockmount base. Contact your nearby CEC field office, or write for Bulletin CEC 1403-X3.

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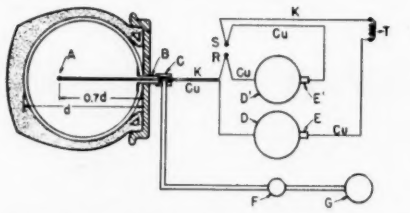


A- Copper constantan thermocouple
B- Valve stem
C- Adapter
D D'- Copper slip rings
E E'- Copper-graphite brushes
F- Rotating joint
G- Precision air pressure gauge
R- Rotating copper-constantan thermocouple
S- Stationary copper-constantan thermocouple
T- Temperature recorder
Cu- Copper lead wire
K- Constantan lead wire

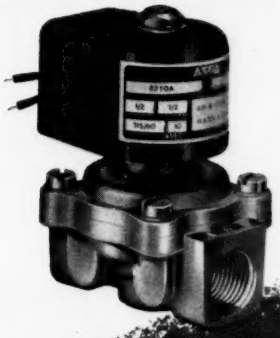
high temperatures, and high temperatures affect the service life of tires, and hence the choice of materials used in them. The new procedure involves the use of a copper-constantan thermocouple inserted through the tire valve. When the tire is rotated under load, the thermocouple gives a precise measurement of the average contained-air temperature, via copper-graphite brushes on copper slip rings.

Foxboro Feeds Food Forumers

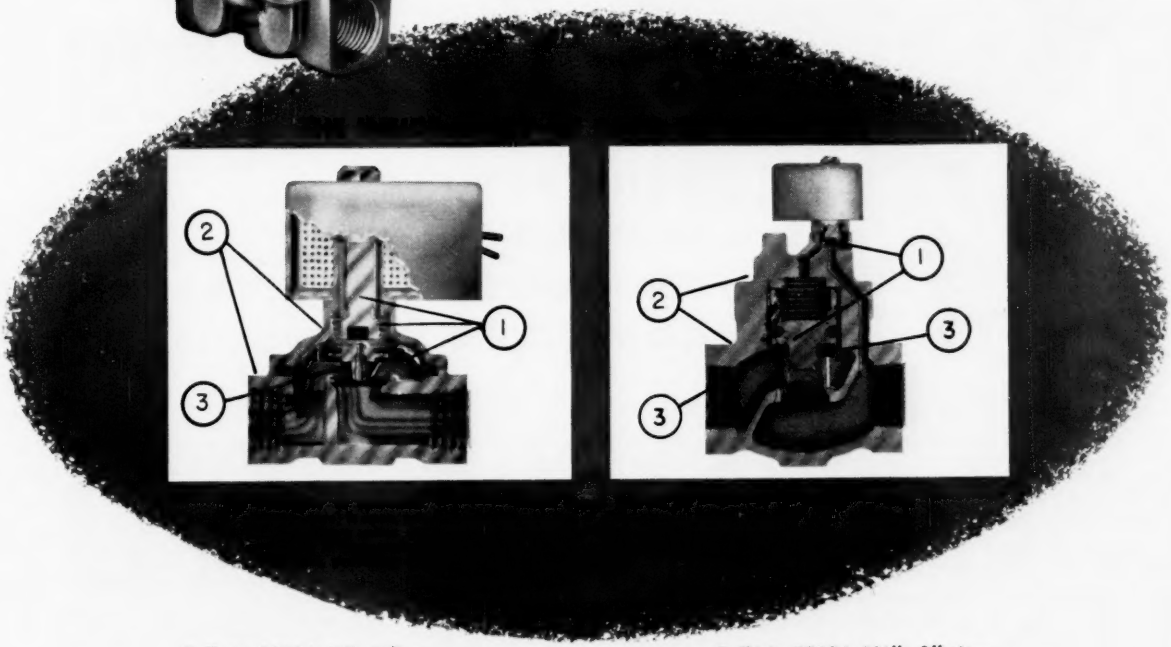
FOXBORO, MASS.—Existing instruments and their application, plus a preview of those being readied for future production, were discussed at an informative Food Forum, held at the Foxboro Co., March 18-20. Electronic measurements such as dew-point quality control, continuous viscosity measurement, and control panels enabling centralized control and continuous processing of food products were the main topics. W. S. Young, manager of Foxboro's Food Industries Div. served as moderator.

SHOWN ATTENDING THE 3D ANNUAL FOOD FORUM AT THE FOXBORO Company, March 18-20, are (seated left to right): L. R. Grant, Carling Brewing Co., Natick, Mass.; A. A. Burzlaff, The Rath Packing Co., Waterloo, Iowa; D. H. Westermann, Miller Brewing Co., Milwaukee, Wis.; W. A. Tansey, The American Sugar Refining Co., Boston, Mass.; J. C. Crudden, The American Sugar Refining Co., Brooklyn, N. Y.; D. Poindexter, The American Sugar Refining Co., Boston, Mass. (Standing left to right): W. S. Young, The Foxboro Company; A. Hohner, The Quaker Oats Co., Chicago, Ill.; J. A. Perry, Cherry-Burrell Corp., Chicago, Ill.; F. W. Velguth, Corn Products Refining Co., Chicago, Ill.; G. L. Hammond, A. E. Staley Mfg. Co., Decatur, Ill.; D. T. Phillips, The Nestle Co., White Plains, N. Y.; W. J. Colyer, Carling Brewing Co., Natick, Mass.; E. Halpin, Atlantic Gelatin Div., General Foods Corp., Woburn, Mass.; and L. T. Mencke, The Quaker Oats Co., Chicago, Ill. Absent when picture was taken: W. L. Reed, Revere Sugar Refinery, Charlestown, Mass.

new complete line of
ASCO 2-way solenoid valves
now available in full range through 3" sizes



Now specifying engineers may select from ASCO's new line of general purpose packless valves in full size range from ⅜ to 3 inches; pressures to 350 p.s.i. Study these valve cross sections and see why ASCO design means dependability in flow-control for air, gas, water, light oil and other non-corrosive fluids.



Bulletin 8210A ⅜"—¾" sizes

1. Simplicity in construction. Only three operational parts: all stainless steel core, stainless steel spring, Hycar diaphragm (for handling all common liquids and gases).
2. Ruggedness. Forged brass bonnet and body insure freedom from porosity.
3. Tight Shut-Off. Assured by resilient disc construction.
4. Compactness. 2¾" face to face; 3¼" pipe center line to top of solenoid; 3 13/16" overall height. (Normally closed, ⅜" x ½" sizes.)
5. Mountable in any position, normally open or normally closed.

Bulletin 8210A 1¼"—3" sizes

1. Simplicity in construction. Even in larger port sizes, moving assemblies have been held to two—bronze piston and stainless steel core.
2. Ruggedness. Extra heavy duty bronze body and bonnet, plus heavy duty operating parts.
3. Tight Shut-Off—assured by resilient disc construction.
4. Elimination of water hammer—assured by slotted "V" type discs.

All sizes have full area ports, continuous duty coils designed for low temperature rise and long life, and are available normally open or normally closed with standard, water tight or explosion proof solenoid.

Whatever the crucial factor in your flow-control application—reliability, compactness, high cycling rate—there is an ASCO valve that meets your need.

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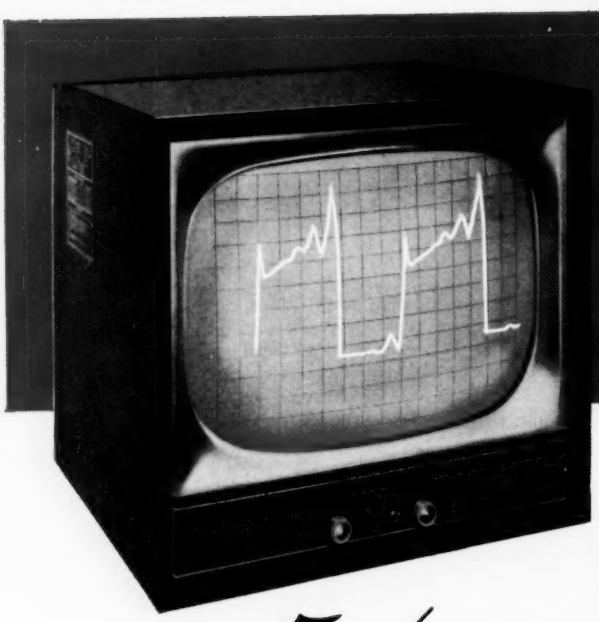

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Show the patterns big, bright and clear . . . so everyone can see!

The Du Mont SlaveScope may be used with any standard low-frequency oscilloscope for applications such as group viewing, production line testing, or computer read-outs. Signals from the deflection plates of the driving oscilloscope are fed through a cathode-follower adapter to the SlaveScope. The oscilloscope pattern is accurately reproduced on the large screen of the SlaveScope.

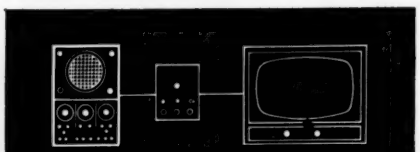
The SlaveScope is supplied with a 10′ connecting cable, but may be used for remote viewing up to 100′ from the driving oscilloscope.

ACCURATE REPRODUCTION: X and Y amplifier linearity of 1% full scale.
HIGH VISIBILITY: Accelerating potential of 6 KV produces bright trace, even under high ambient light conditions.
DEFLECTION FACTOR: Dependent upon driving oscilloscope. For example, when used with Du Mont Type 401, 100 millivolts full scale; when used with Type 403, 1 millivolt full scale.
FREQUENCY RESPONSE: DC to 100 KC, dependent upon deflection amplitude.
IDENTICAL AMPLIFIERS: Identical X and Y amplifiers.

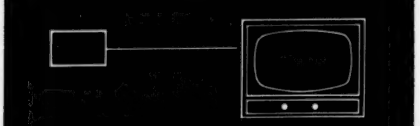
TYPE 343 **17"** rectangular CRT, rack mounted **$980.00**

TYPE 345 **21"** rectangular CRT, for bench use **$870.00**

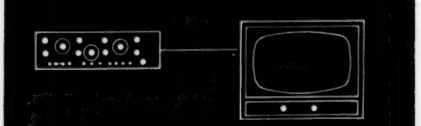
(with P4 screens. P1, P2, P7 screens available at slightly higher cost.)



For coupling SlaveScope to master oscilloscope, Type 2622 Cathode Follower Adapter prevents loading of deflection circuits, assuring accurate reproduction of test patterns. Type 2622, $105.00



Signals from high output, low-frequency transducers may be fed directly into SlaveScope. X and Y amplifier sensitivity 1 volt/inch.



SlaveScope used with Type 2628 Amplifier-Sweep Adapter as a complete, laboratory quality, general purpose low-frequency oscilloscope.

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Education News

• ASEE (American Society for Engineering Education) has received a grant of $10,000 from the National Science Foundation for a study of how American engineering colleges may attract and keep top-flight engineering teachers for their growing number of students.

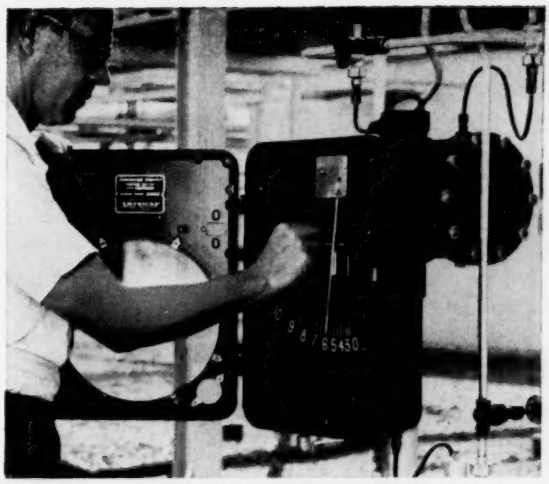
• At the recent fifth annual mathematics tournament attended by more than 900 upstate-New-York high-school math students, William J. Morlock, general manager of GE's Technical Products Department, predicted "a computer in every high school," based on the rapidly approaching mass production of the machine.

• Scholarships: Hughes Aircraft announced a new high-school scholarship plan granting $400 to 12 seniors and juniors selected from public schools in the Los Angeles area who will first get a chance to work for 10 weeks (with pay) at the Hughes labs.—Stromberg-Carlson has given two scholarships for electronic engineering to two sons of employees, paying full tuition plus $250 a year. And six teachers have been named winners of $500 scholarships each to further their education in science and math during the summer months.—IT&T has created a scholarship at Carnegie Tech for an undergraduate in the departments of Electrical Engineering, Mathematics or Physics.—The IBM Post-Doctoral Industrial-Research Fellowship for 1957/58 was granted to Miss Winifred Asprey, Chairman of the Department of Mathematics at Vassar College.

Miss Asprey

• Grants: The National Science Foundation has announced 235 grants, totaling more than $4.3 million for the first quarter of 1957. This brings the grants to a grand total of $54.3 million since the beginning of the program in 1951. NSF also has granted $138,000 to 18 colleges and universities to support in-service institutes designed to improve the training of high-school teachers of science and math.—The Engineering Foundation endowment fund recently has been increased by one hundred shares of General Motors stock, a gift of Orlan W. Boston, professor emeritus of Mechanical and Product Engineering at the University of Michigan. The current endowment fund is in the neighborhood of $1.5 million.—A new matching-grant program, designed to "encourage increased individual support of the nations colleges and universities" has been initiated by Dow Chemical for its employees. Any gift to an accredited four-year college or university will be matched by the same amount from the company. Dow's over-all gifts to education in 1957/58 will total $310,000 plus another $300,000 to be made available to colleges and universities for specific research projects expected to be beneficial to the company.

• Courses: MIT's special summer program, extending from June 11 to September 14, includes courses on infrared spectroscopy, missile aerodynamics, stain gages, analog-digital conversion techniques, noise reduction, weather radar, and instrumental analysis.—University of Michigan College of Engineering will give five different courses on digital computers from August 19 to 30.

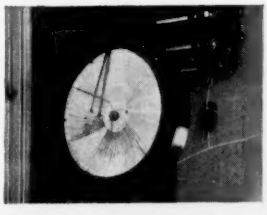


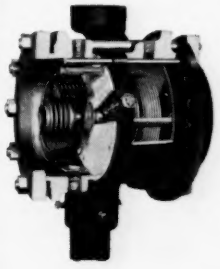
You can't match AMERICAN® DRI-FLO METERS for versatility

You can't match American® DRI-FLO Meters for versatility, accuracy and proven dependability.

Above, an American DRI-FLO Meter is used to measure ethane reflux flow on a de-ethanizer unit in a gasoline plant at 500 psi and 80 to 100° F, typical of one of the many installations meeting the most exacting requirements.

Below, a DRI-FLO manometer is shown measuring lease gas and is used in conjunction with a 30-year-old recording mechanism—proof of the versatility and long service life built into American products.





DRI-FLO Meters bring American-Westcott precision, simplicity of installation and maintenance, with maximum resistance to corrosive materials, to orifice meter measurement. Differential ranges: 20", 50", 100", and 200"; Working pressures 1000 and 5000 psi; Ambient temperatures of −25 to 175°F.

Write for full information.

AMERICAN® METER COMPANY
INCORPORATED (ESTABLISHED 1836)

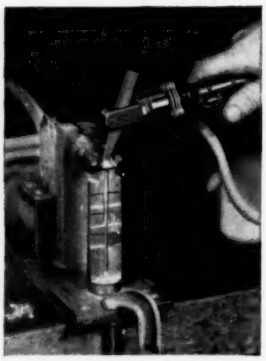
GENERAL SALES OFFICE: Somerton, Philadelphia 16, Penna. • Albany Alhambra • Atlanta • Baltimore • Birmingham • Boston • Chicago Dallas • Denver • Erie • Houston • Kansas City • Los Angeles • Minneapolis • New York • Omaha • Pittsburgh • San Francisco • Seattle Tulsa • Wynnewood. IN CANADA: Canadian Meter Company, Ltd., Milton, Ontario • Calgary • Edmonton • Regina

SUPPLIERS TO THE GAS INDUSTRY for Ironcase, Tinned Steelcase, Aluminumcase and Welded Steelcase Meters • American-Westcott Orifice Meters Instruments • Reliance Regulators • Apparatus • Valves

For more information circle **30** on inquiry card.

Resistance Heat Soldering Ends "Cold Flow" Rejects-- Insures Strong, Uniform Joints

In an increasing number of plants, resistance heat soldering has practically licked the problem of non-uniform solder joints and "solder voids."

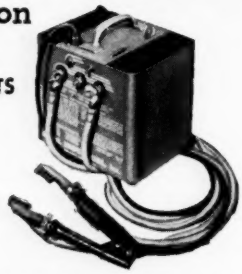


Resistance heat soldering of parts with preformed soldering rings, using "Pencil" attachment, and jig set-up.

The resistance heating principle makes cold flow joints all but impossible. High amperage, low voltage current, passing *through* the joint to be soldered, heats the joint above the temperature required to melt the solder. Heat is concentrated at the point of contact to prevent burning of nearby parts. No set-up or pre-heating is necessary. Solder adheres instantly and uniformly over and between the surfaces to be joined, to make the strongest joint it is possible to make. Heat is adjustable by thumb switch and instantly controlled to meet job requirements.

For the Most Complete Information Available on Resistance Heat Soldering, Send for Data on

IDEAL THERMO-GRIP SOLDERING SETS



Used for more resistance heat soldering than any other type. Complete details on all models, from the 450-watt light duty model up to the 7500-watt unit for large brazing jobs. Also application data on various attachments, including "grip-and-heat" "Pliers", "Fork" and "Pencil" attachments. All units are fully portable.

PROVED BETTER FOR JOBS LIKE THESE:

- Hermetic closures
- Tube joints
- Bellows and diaphragms
- Bourdon tubes
- Wherever strong, vibration-proof or air-tight seals are required.

SOLD THROUGH AMERICA'S LEADING DISTRIBUTORS
In Canada: Irving Smith, Ltd., Montreal

GET FULL DATA FREE

IDEAL INDUSTRIES, Inc.
1420-F Park Avenue, Sycamore, Illinois

Please send full information and technical data on IDEAL Thermo-Grip Soldering and Brazing Equipment.

Name_____

Company_____

Address_____

City_____ Zone____ State_____

For more information circle **31** on inquiry card.

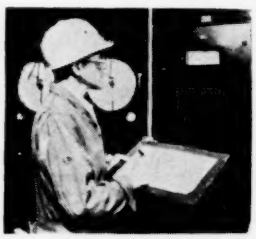
News Bits

UNION SWITCH AND SIGNAL has developed a Teletype tape storage feeding system for sorting cars in freight yards.

FIRST NATIONAL BANK OF ATLANTA has requested bids on a complete electronic bookkeeping system.

INTERNATIONAL RECTIFIER CORP. has developed 16,000-volt silicon diodes.

BALDWIN-LIMA-HAMILTON's SR-4 tank weighing system is a crucial part in new process for producing a new hydride needed in the synthesis of cortisone, according to report from Metal Hydrites, Inc.



B-L-H SR-4 Tank Weighing System

Askania Visitors

ASKANIA REGULATOR CO. was host to a group of Japanese representatives examining American steel automatic control techniques.

FULTON SYLPHON DIV. recently had Spanish Ministry officials studying technology and manpower requirements as its guests.

Television marked another communication milestone Sunday, April 14, with what is believed to be the world's first transmission of TV picture on a light beam. Shown on the program "2000 A.D." carried over Boston's WBZ-TV, the demonstration was made possible by a special shutter, developed by **BAIRD-ATOMIC, INC.,** that can go "on and off" millions of times per second.

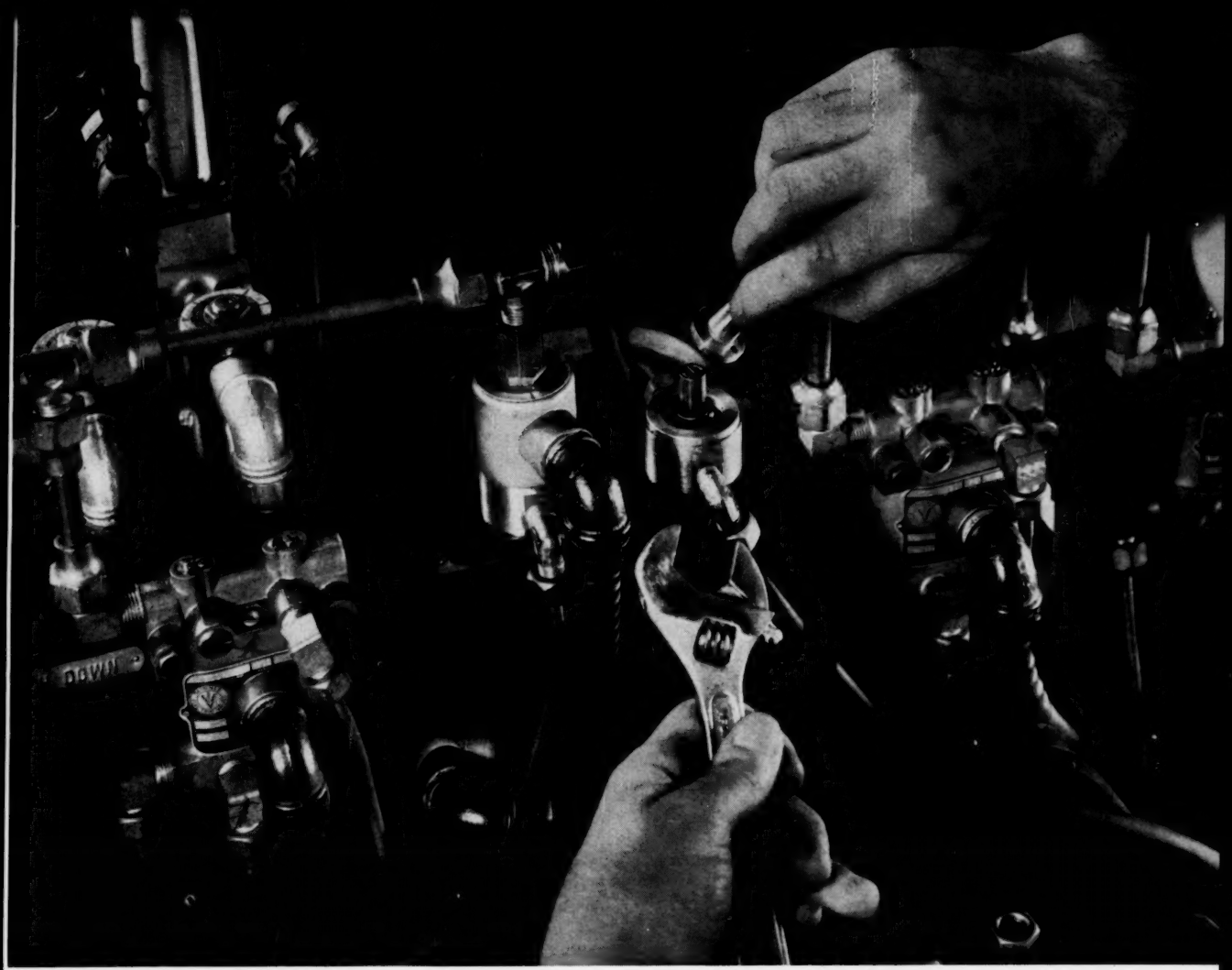
SUN OIL CO. advertises that motorists can get at the pump a blend of "tailored motor fuel with exact octane your car needs—without wasting money for octane your car can't use."

NEMA has announced formation of a special information committee to keep abreast of new developments in the semiconductor field.

DUMONT LABORATORIES have devised a completely automatic "dial-direct" mobile two-way radio-telephone system.

MINE SAFETY APPLIANCES CO. has furnished "MinePhones," a complete two-way communication system, to the Sullivan Mine at Kimberly, British Columbia, which enables a traffic control man to keep in constant touch with the operators of six electric locomotives. It also lets them talk with each other. They have been an important contribution to safety in mines.

Circle **32** on inquiry card. ⟶



Skinner Solenoid Valves are easier to maintain and service because of their simplified design

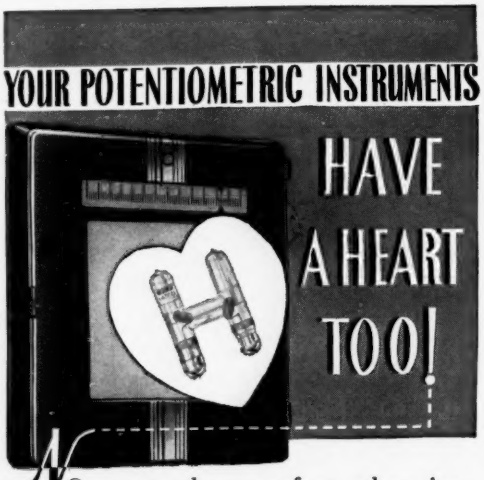
The man shown above is cleaning a Skinner Solenoid Valve. He has disassembled it by hand without removing it from the line. Simplicity of design makes this simple maintenance and service feature possible. The design of Skinner valves is such that coils and other parts are interchangeable and easily, quickly replaced. They are readily available, too — reducing the stocking of spare parts to a minimum.

Skinner Solenoid Valves are made of the very finest materials available and contain only two moving parts. Their joints are heli-arc welded on special electronically controlled equipment. Their coils, manufactured to UL standards, will operate for years without burnout. Their positive spring returns eliminate sticking. And they have no packing to wear out and cause leakage.

If you are looking for solenoid valves that will give you longer trouble-free performance, look to Skinner valves. For complete information on Skinner's line of 2-, 3- and 4-way valves, write us or contact a Skinner representative. Write Dept. 416.

Skinner Solenoid Valves are distributed nationally

SKINNER ELECTRIC VALVE DIVISION
NEW BRITAIN CONNECTICUT
185 EDGEWOOD AVENUE



NO matter how perfect otherwise, the human organism isn't much good without a dependable heart. The same is true of your automatic temperature and pH control instruments.

The "heart" of most such instruments for the past quarter century has been the Eplab Standard Cell. It is a "yardstick" for translation of voltage to temperature or pH. The first American commercial cell of its type, constantly improved by research, it is "as standard as sterling".

Get ACCURATE temperature or pH control with potentiometers and make sure the standard cells are EPLAB.

The Eppley Laboratory, Inc. 2 Sheffield Ave., Newport, R. I.

EPLAB *Standard* CELLS
FOR POTENTIOMETRIC INSTRUMENTS
"As Standard as Sterling"

For more information circle **33** on inquiry card.

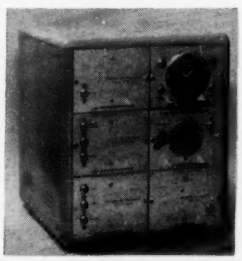
NEWS—CONTINUED

ELECTRODATA DIV. has installed 147 computers, nationwide,—including the large Datatron system and the desk-size E101.

POWERS REGULATOR CO. has solved the problem of how to eliminate fluctuating temperatures in cooling chamber of Lindberg Company's continuous atmosphere furnace by replacement of electric control on water jacket with a gradual-acting self-operating temperature regulator.

GENERAL PRECISION LAB. has developed transmission of narrow-band television pictures over ordinary telephone cable pairs.

QUARTZ CLOCK Manufactured by the Swiss firm Ebauches S.A. is now on the market. Its accuracy is 0.01 second per day.



Quartz Clock

Guide-O-Matic tractor

BARRETT-CRAVENS Guide-O-Matic tractor used at Nalley's, Inc. food plant requires no operator. Guidance is accomplished electronically from a guide wire embedded in the floor with no physical connection.

HIGH VOLTAGE ENGINEERING CORP. will install next year a new type Van de Graaff particle accelerator in Canada's Chalk River nuclear installation. The 10-million-volt "atom smasher" will be equipped with a switching magnet that makes it possible to switch the intense beam of particles into any of four directions.

INDIANA STEEL PRODUCTS CO. has announced perfection of a new oriented ceramic magnet material. The light weight of Indox V makes its energy product comparable to Alnico V (on an equivalent weight basis) and has the advantage of not containing any critical materials.

AIRBORNE INSTRUMENTS LAB. furnished Ford Motor Co. with a specially developed all-electronic ignition-distributor test stand displaying the parameters of performance on a 17″ television tube, which facilitates calibration.

All-electronic ignition-distributor test stand

Electronic detector

SERVO CORP. OF AMERICA has developed for the C&O Railroad an electronic detector for detecting overheated journal boxes on railroad cars passing a given point.

NEW FROM GENERAL ELECTRIC . . .

52% MORE USABLE PANEL SPACE

GENERAL ELECTRIC'S NEW PYROMETER SAVES SPACE WITH PRINTED CIRCUITS AND MINIATURE COMPONENTS

A new pyrometer that fulfills industrial heat treating requirements of close reproducible control at low cost is now available from General Electric.

THE SMALLER SIZE of the new HP-30 Series Pyrometer means that valuable panel space can be conserved. The size reduction of the instrument was made possible through use of printed circuits, high strength magnet material, and miniature components.

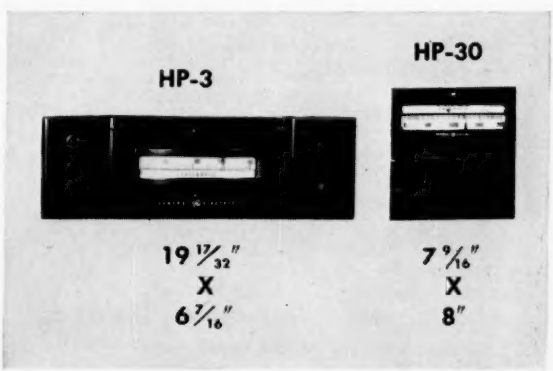
AN EXCLUSIVE FEATURE of General Electric's new pyrometer is automatic lead length compensation. The HP-30 offers lead length compensation up to 25 ohms in low ranges and 90 ohms in higher ranges.

HIGH ACCURACY and control sensitivity are maintained at levels associated with General Electric's HP-3 Pyrometer. The new instrument features ±.5% accuracy and .1% to .5% sensitivity adjustment.

EASY CONNECTIONS are possible with the HP-30 because it features knockouts on the top and side of the controller case. Electrical connections may be made to the front or back of a printed circuit board.

FLEXIBILITY of the new pyrometer allows flush or surface mounting, interchangeable control forms, and range changes that can be made in the field. In addition to six basic control forms, special variations to solve specific control problems are available on request.

For further information, write to Section 587-8, General Electric Company, Schenectady 5, N. Y., or contact your nearest General Electric Apparatus Sales Office.



COSTLY PANEL SPACE can be saved with the new HP-30—companion to the widely accepted HP-3. Both General Electric instruments feature high accuracy and close reproducible control.

GENERAL ELECTRIC

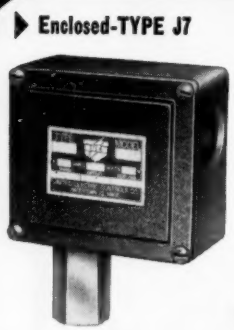
For more information circle **34** on inquiry card.

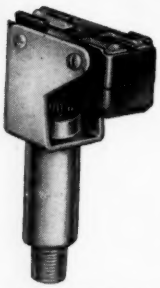
UNITED ELECTRIC

Multi-Purpose

PRESSURE CONTROLS J7 | J40

▶ Enclosed-TYPE J7





▶ Skeleton-TYPE J40

These controls are compact, precision-built, rugged and inexpensive. Type J7 is ideal for controlling air, gas or liquid pressures up to 500 psi . . . Type J40 for pressures up to 250 psi.

Adjustable Pressure Ranges	J7 . . . various models cover ranges between limits of 0 and 500 psi J40 . . . various models cover ranges between limits of 0 and 250 psi
Switch Ratings	15 amps or 20 amps at 115 or 230 volts A.C., also D.C. switches upon specification
Switch Types	N.C., N.O., or Double throw, no neutral position
Electrical Connections	J7 . . . screw type terminals on switch standard J40 . . . solder type terminals on switch standard
On-Off Switch Differential	Fixed and uniform throughout specified range is standard
Mounting	J7 . . . ¼" NPT female, brass fitting standard J40 . . . ⅛" NPT male, brass fitting standard
Variations	Design variations are available upon specification
Applications	On industrial equipment and engine applications . . . marine, aircraft or special purpose

Although **UNITED ELECTRIC** *offers a complete line of temperature, pressure and vacuum controls . . . UE application engineers specialize in solving unique problems.*

Send for full particulars today. Bulletins available upon request. Type J7 . . . Bulletin No. 5-7, Type J40 . . . Bulletin No. 5-9

United Electric Controls COMPANY

82 SCHOOL STREET, WATERTOWN, MASS

For more information circle **35** on inquiry card.

NEWS—CONTINUED

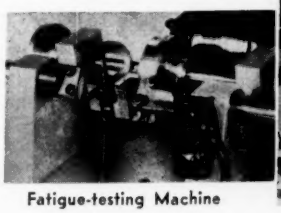
AMERICAN CHAIN & CABLE'S Tucon Microhardness Tester has been adapted by Alco Products, Inc. to determine hardness of chrome-plated *interiors* of metal castings. This is called an all-important new procedure in inspecting methods.

PRATT & WHITNEY's jet engine development lab has installed a 5000-gph Penfield MA-500 Demineralizer to insure supply of ultra-pure water for its development work.

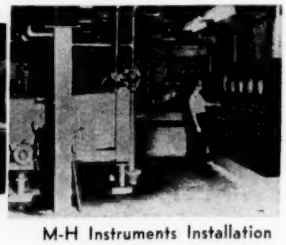
TEXAS INSTRUMENTS announced that its semiconductor-grade silicon is now made commercially available to other transistor manufacturers.

BELL LABS. announces development of hi-speed data transmission equipment ("data subset") capable of sending 1000 words per minute—or 16 times faster than conventional teletypewriters.

N.B.S. has developed a machine for fatigue-testing small diameter wire, in studies of spring materials.



Fatigue-testing Machine



M-H Instruments Installation

MINNEAPOLIS-HONEYWELL instruments have been installed in the new mill of the New York and Pennsylvania Co. to regulate and record size mixing, cooking time, flow through the storage tanks, and simultaneous supply to the four Foudrinier machines.

LEEDS & NORTHRUP's new control plant, located at North Wales, Pa. has been named one of the "Ten Best Plants of 1956" out of more than 1000 entries in the 23rd annual contest conducted by "Factory Management & Maintenance". L&N was the only instrument plant selected.

Other Computer Concoctions . .

• **REEVES INSTRUMENT CORP.** has shipped a new Reeves 400 REAC Computer to the French Commisariat a l'Energie Atomique installation near Paris. It will facilitate studies of new uses for atomic energy.

• **IBM** announces that the American National Insurance Company of Galveston has purchased 705 Model II Electronic Data Processing Machine. It will be used for processing policies, loan accounting, and notice billing.

• **PHILCO CORP.** is building its completely transistorized TRANSAC S-2000 computers for on-line or off-line commercial, scientific and military applications.

• **PAN-AMERICAN WORLD AIRWAYS** announces installation of a new Teleregister system to determine availability of seats on any of the airline's flights to any part of the world. Capability—65000 flights; time to get information—4 seconds.

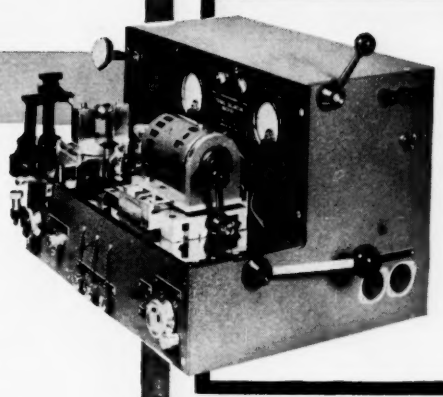
Locates Measures Corrects

DYNAMIC UNBALANCE

of miniature high speed gyro rotors

Detailed information is in Instrument Data Sheet 211, available upon request to Technical Literature Section.

decker DYNAMIC BALANCER



without removing the rotor from the mount

Even miniature missile type gyro rotors can be balanced in 6 to 10 minutes with the DECKER DYNAMIC BALANCER. And ultimate balance is generally limited only by the quality of the rotor bearings.

Designed specifically for high speed rotors requiring maximum possible precision of balance, the Model 211 Dynamic Balancer is capable of handling any rotor which may be electrically driven at 10,500 rpm or higher.

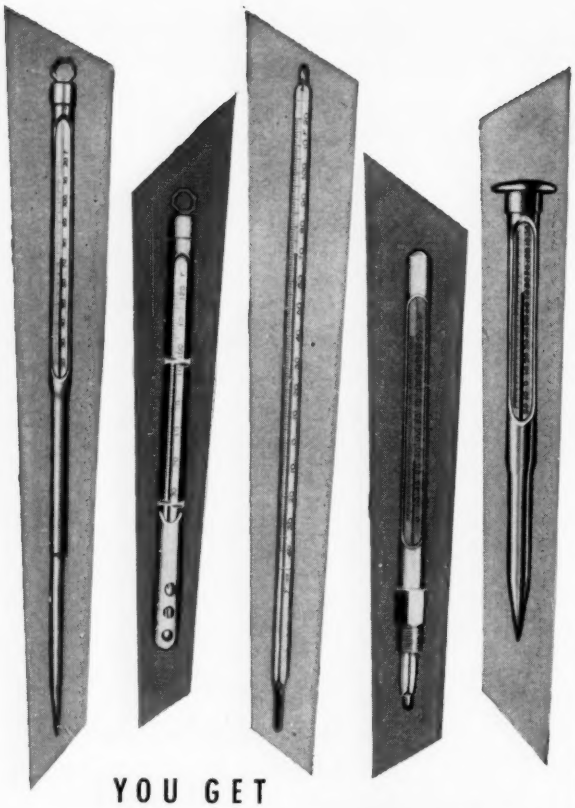
The Balancer offers, on a single portable chassis, everything needed for precision dynamic balancing. Included are the necessary equipment for rotor mounting, measurement, and location of unbalance, plus a precise metered automatic drill for unbalance correction.

- **Maintains laboratory type precision balance on a production basis**
- **Does not require a skilled technician**
- **Automatic marking of point of unbalance**
- **Drilling performed without removing rotor.**
- **Precise indication of degree of unbalance**
- **Automatic speed control**
- **Rapid run up to proper speed**
- **Completely self contained and portable (11" x 15" x 21")**
- **Rapid work change over**

decker AVIATION CORPORATION

1361 Frankford Ave., Philadelphia 25, Pa., PHONE GArfield 5-2300

For more information circle **36** on inquiry card.



YOU GET

dependability PLUS

WITH MOELLER TEST THERMOMETERS

because our business is the
design and manufacture of temperature measuring
instruments—and has been since 1867.
Moeller Test Thermometers are guaranteed for permanent
accuracy and are made according to specifications
set forth by the United States Government,
A.S.T.M., and other Societies and Associations.
Mail the coupon today for descriptive
literature on Moeller Test Thermometers.

MOELLER INSTRUMENT COMPANY
132nd ST. and 89th AVE.
RICHMOND HILL 18, N. Y.
Representatives in Principal Cities

Gentlemen: Without obligation, please send me Catalog No. 800 on Moeller Test Thermometers, Hydrometers, Temperature and Hydrometer Conversion Tables.

NAME .....
FIRM .....
ADDRESS .....
CITY..... ZONE..... STATE.....

For more information circle **37** on inquiry card.

NEWS —CONTINUED

• **MINNEAPOLIS-HONEYWELL** reports that electronic "brains" have a long way to go to match human brainpower. Employees of the company submitted 5,630 better ways of doing things during the year 1956.

• **J. B. REA CO.** is expanding its computing service facility, making it one of the most complete and versatile computing services in the Western United States.

• **REMINGTON RAND** is compiling electronically a complete concordance of the Holy Bible. The entire revised standard version of the Bible was put on four reels of UNIVAC metal magnetic tape.

• **ELECTRONIC ASSOCIATES** announce the addition of a completely equipped digital computer to the facilities of the Princeton Computation Center. Both analog and digital computers will be available.

• **ESSO RESEARCH** announces plans for a large-scale technical computing center at Linden, N. J., the heart of which will be an IBM 704. Only one other 704 unit is in use in the oil industry.

• **NATIONAL CASH REGISTER** reports substantial reduction in cost of keeping business records with a new type electronic data-processing system designated NCR 304. It will provide automatic accounting, auditing, reporting and other business record keeping functions in one continuous high-speed operation.

Stock Report

Any further information concerning any of the following issues may be obtained from the Research Department, Bache & Co., 36 Wall Street, New York 5, N. Y.

New York Stock Exchange:

	Price Range For 1957 Thru May 17th		
	HIGH	LOW	PRICE AS OF MAY 17th
ACF Industries	64 7/8	58 1/8	64 3/8
Aeroquip Corp.	30 7/8	20 1/8	29 3/8
Allis Chalmers	36 1/4	32	35 3/4
American Chain & Cable	61 1/4	48 3/4	60 1/4
American Machine & Foundry	40 1/8	31 5/8	39 5/8
American Machine & Metals	56 7/8	41	55 7/8
American Optical	37 7/8	33	37 7/8
American Tel. & Tel.	179 7/8	170 1/2	178 3/4
Beckman Instruments	42	35 1/4	38
Bell & Howell	50 1/2	36 1/2	41
Bendix Aviation	66 3/4	57 1/2	66 1/4
Boeing Airplane	61 1/8	45	50 1/2
Bullard	29 1/8	22	23 3/4
Bulova Watch	21	19 3/4	19 3/4
Burroughs	47 1/4	33 7/8	46 1/2
Carborundum	45 5/8	38 3/4	41 7/8
Cincinnati Milling Machine	50 1/2	39 3/4	43 3/4
Clevite	23 3/4	18	23 1/2
Columbia Broadcasting "A"	36 1/8	29 3/4	35 3/8
Consolidated Electronics	35 1/2	28 1/4	29 5/8
Cornel Dubilier	27 1/2	21 5/8	25 1/2
Corning Glass	72 1/2	57 1/4	72 1/2
Curtiss-Wright	47 3/8	38 3/4	45 3/8
Cutler Hammer	64 3/4	51 1/2	58
Consolidated Electrodynamics	46 3/4	31 1/4	42 1/2
Davstrom	40 3/8	29 5/8	38 7/8
Dobeckmun	30 1/4	24 1/4	29
Douglas Aircraft	91	75 1/8	83 1/2
Eastman Kodak	98 1/4	81 3/4	97 5/8
Eaton Manufacturing	64 1/4	55 1/2	56 3/4
Electric Auto Lite	40 3/8	30 1/4	37 1/8
Elgin Watch	14 1/8	11 1/8	12 1/4
Food Machinery & Chemical	65 1/4	53	64
Gamewell	36 1/2	28	31 1/2
Garrett	54	46 1/4	49 3/4
General Dynamics	68 5/8	54 3/8	65 7/8
General Electric	67 1/8	52 3/8	67 1/8
General Instrument	8 1/8	6 1/4	7
General Mills	69	59 3/4	63 1/8
General Precision Equipment	44 3/4	36 1/2	43
General Railway Signal	33	27	31
General Telephone	45 1/4	39 1/2	43
General Time	30 1/2	24	24 1/2
General Tire & Rubber	93 1/4	55 1/4	85 1/4
International Bus. Machine (new)	345	288 1/2	323
International Tel. & Tel.	37 1/4	29 1/2	36 3/4
ITE Circuit Breaker	43 1/2	40 3/4	41 1/2
Lockheed Aircraft	57 1/8	44 1/4	46 5/8

Continued on page 1054

Perfect performa

by PO METE

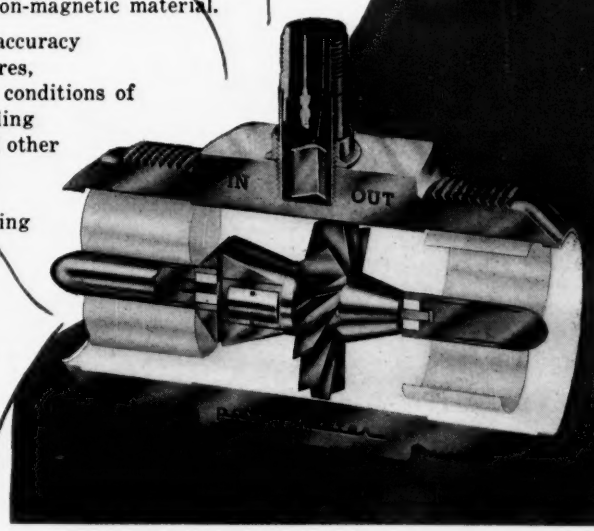
POTTER Flow Control Systems are currently operating at temperatures as low as −455°F. and as high as 1000°F., at pressures up to 35,000 psi—with no ceiling.

The POTTERMETER Flow Sensing Element, is based on a unique venturi design with a *bearingless*, hydraulically-positioned rotor, and can be made of stainless steel or any non-magnetic material.

POTTER systems feature high accuracy over a wide range of temperatures, pressures, density and viscosity conditions of liquids and liquefied gases, including acids, caustics, hydrocarbons and other corrosives. They are shock and vibration-resistant and can be utilized with a variety of indicating totalizing, recording and/or control instrumentation.

Only POTTER makes the POTTERMETER

Write TODAY for Bulletin T1



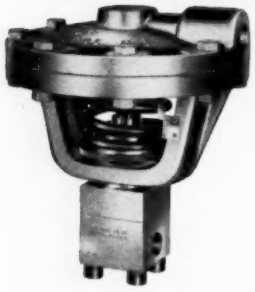
POTTER

POTTER AERONAUTICAL CORP.
U. S. Route 22, Union, New Jersey
MUrdock 6-3010

For more information circle **38** on inquiry card.

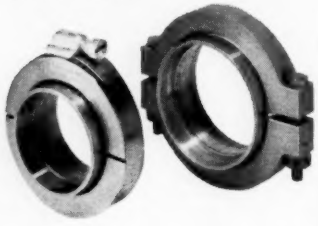
MINIATURIZATION

From Pilot Plant to Process



"BANTAM" 500 SERIES

Throttling "Bantam" Diaphragm Control Valves for all standard control valve uses, Cv of 0.6 and below, up to 1000 psi and 500°F, characterized, renewable trim, 316 stainless steel and teflon only wetted surfaces, low in hysteresis, size and weight, a modern design of control valve. 2000 series "Bantam" Control Valves available for on-off service.

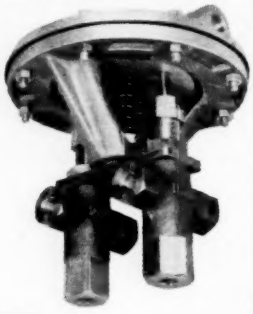


TUBE AND PIPE CONNECTORS

For use in such systems as aircraft or marine applications where weight is a factor, these connectors replace standard flanges. Available in various materials, in male or female socket or butt weld design, for tubing, and up to schedule 40 pipe.

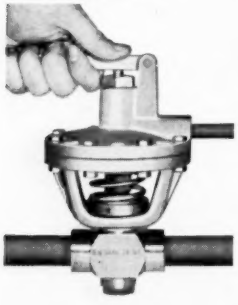
"DEMI" PACKLESS VALVES

For services when packing is a problem, manifolding of small valves in one unit, these low cost valves have a great popularity. For services up to 1500 psi and 500°F., screw, toggle, or diaphragm operated, the "Demi" line is ideal for panel mounting up to five valves in one block.



WHIFFLETREE OPERATOR

Two valves operated simultaneously by one operator. Valves may be globe or three-way and have a multitude of piping arrangements for mixing and routing applications.



MANUAL RESET

Wherever control air on dangerous or toxic process flows must be blocked for safety, on air failure until manually reset, these valves insure against disaster. Standard sizes ¼" and ½" I.P.S.

SAUNDERS VALVES — AIR OPERATED

Plastic valves, 2" and below, metal valves 1" and below, G. W. Dahl Company, Inc. diaphragm operators on these valves provide simple, sure automatic operation. Each application must submit full flow information.

Write us for complete technical information, or the address of our representative in your area.

George W. DAHL Company

BRISTOL, RHODE ISLAND

For more information circle **39** on inquiry card.

NEWS—CONTINUED

New York Stock Exchange:

Continued from page 1052

	HIGH	LOW	PRICE AS OF MAY 17th
Magnavox	40 1/2	35	40 1/8
Minneapolis-Honeywell	98	73 1/2	97 1/2
Minnesota Mining & Mfg.	77 1/4	58	74
Motorola	47	35 3/4	47
National Acme	80 1/2	69	70 1/2
National Cash Register	64 3/4	46 1/4	62 1/4
North American Aviation	39 1/4	27 1/2	33 3/4
Northrop Aircraft	28 1/8	24 1/8	26
Otis Elevator	49	39 1/8	48 5/8
Philco	18 3/8	14 1/8	16 5/8
Radio Corp. of America	40	31 5/8	38 3/4
Raytheon	22 1/4	16 3/8	21 5/8
Reeves Manufacturing	21 1/4	17 3/4	19 3/8
Robertshaw Fulton	32 1/2	25 5/8	30 5/8
Sangamo Electric	39 3/4	31 1/4	38 3/4
Sperry Rand	24 3/8	20	23
Square D	32 7/8	28 1/8	32
Standard Coil Products	9 3/8	6 1/2	7 7/8
Starrett (L.S.)	85	62 1/2	83 1/4
Stewart-Warner	41 5/8	31 7/8	40 1/8
Sylvania Electric	46 1/4	39 5/8	44 1/8
TelAutograph	8 3/4	6 1/2	6 1/2
Texas Instruments	24 7/8	15 7/8	23 7/8
Thompson Products	89 3/4	69 1/2	86 1/2
Tung-Sol Electric	34 1/4	27 3/8	32 1/2
Underwood Corp.	30 3/8	23 3/4	29 7/8
Union Carbide Corporation	121 3/4	100 5/8	121 1/2
Western Union	20 3/8	17 7/8	18 3/8
Westinghouse Air Brake	33 1/8	26 1/2	32 3/8
Westinghouse Electric	62 1/4	52 3/8	61 3/8
Worthington Corp.	63	52 1/4	63

American Stock Exchange:

Price Range For 1957 Thru May 17th

	HIGH	LOW	PRICE AS OF MAY 17th
Electronic Communications, Inc.(a)	11 3/8	8	8 1/4 - 9 1/4 (1)
American Meter	34 1/8	31 1/2	34 1/8
Aro Equipment	22 3/4	17 1/2	22 1/4
Belock Instrument	13 5/8	9	9 3/4
Benrus Watch	8 1/2	6 7/8	7 3/4 - 8 (1)
Breeze Corp.	7 7/8	5 3/4	7
Barry Controls, Inc. "B"	11 1/2	10	10
Clark Controller	31	25 1/2	27 1/4
Clarostat Mfg.	5	3 3/8	4 7/8
Clary Corp.	4 7/8	4 1/4	4 5/8
DuMont Laboratories	6 1/8	4 5/8	5 1/4
Dynamics Corp. of America	7 5/8	5 3/4	6 1/2
Electronics Corp. of America	12 7/8	9 7/8	11 3/4
El-Tronics	3 7/8	2 1/4	2 3/4
Fairchild Camera & Instrument	22 3/8	16	17 1/8
Globe-Union	20 3/4	16 5/8	19 1/2
Hazeltine Corp.	44 1/2	30 1/2	41 1/2
International Resistance	6 1/8	4 7/8	5 1/4-5 3/8 (1)
Lear, Inc.	8 3/4	7	7 1/4
Litton Industries	40 7/8	29 1/2	40 3/8
National Research	26 5/8	17 1/2	23 3/4
Neptune Meter	32	27 1/4	29 1/4-29 3/4 (1)
New Haven Clock	9/16	1/4	5/16 - 3/8 (1)
Norden-Ketay	11 3/8	7 7/8	11 3/8
Nuclear Corp. of America "A"	2 1/8	3/4	1 5/8
Pneumatic Scale	25	23 3/4	24-24 3/4 (1)
Reliance Electric	48 5/8	36	46 1/2
Servo Corp. of America	6 3/8	4 5/8	5 3/4 - 6 (1)
Servomechanisms	12 3/8	9 1/2	12 1/8
United Shoe Machinery	45 7/8	40 1/4	41 1/8
Wallace & Tiernan	32 1/2	25 7/8	28 1/4
Waltham Watch	2 1/4	1 1/2	1 7/8

a) Formerly Air Associates
(1) Not Traded - Bid - Asked

Over-The-Counter

QUOTATION AS OF MAY 16th

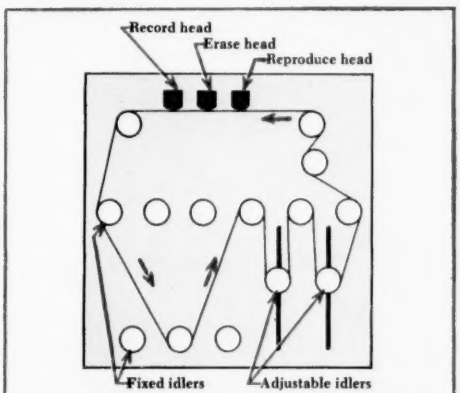
	BID	ASKED
Aerovox Corp.	5 5/8	5 7/8
Aircraft Radio Corp.	19 3/4	20
Argus Corp.	17 1/2	18 1/4
Eitel-McCullough Co.	34	35
Electronics Associates	76	77
Elox Corp. of Michigan "A"	8 1/2	8 3/4
Elox Corp. of Michigan "B"	8 3/8	8 7/8
Erie Resistor Corp.	13	13 3/8
G. M. Giannini	21	21 1/2
Liquidometer Corp.	7 3/4	8 1/8
P.R.Mallory & Co.	48 1/2	48 3/4
W. L. Maxon	6 3/8	6 5/8
Penn Controls, Inc.	18 3/4	19 1/2
Speer Carbon, Inc.	29 1/2	30
Sprague Electric	34	34 1/2
Taylor Instrument	73 1/2	75 1/2
Telecomputing Corp.	4 3/8	4 1/2
Topp Industries	8 5/8	8 7/8
Varian Associates	15 1/2	15 5/8
Vitro Corp. of America	24 5/8	24 3/4

How to use the recorder that chases its tail

The continuous loop solves a variety of tricky problems

At first glance the tape-loop recorder is rather like a puppydog chasing its tail. But don't be fooled – electronically, it is as interesting as a re-invention of the wheel. And you can share the challenge of its practical uses.

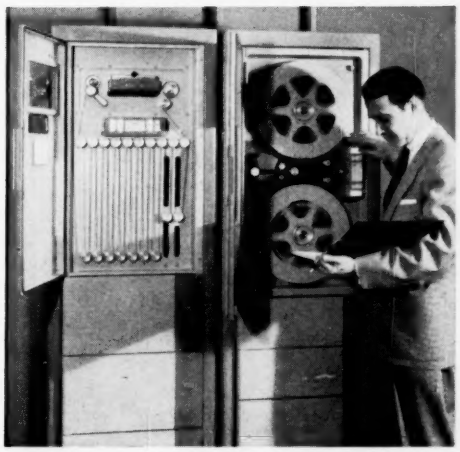
Are you waiting for lightning to strike? Let a tape-loop recorder stand the watch. It has infinite patience and a perfect sense of anticipation. The tape loop continuously records and erases until an important event takes place. At that moment everything is on the loop – even the important instants before. The tape loop either stops at the end of a cycle or it starts up a reel-to-reel recorder to copy the data. This scheme is used to study natural phenomena, to handle intermittent communications, and to collect data on abrupt mechanical or electrical failures.



The tape loop cycles in a period equal to loop length divided by tape speed. Movable idlers plus use of varying numbers of fixed idlers accommodate any loop length from minimum to maximum. Data can be repeated indefinitely or can be continuously erased.

For time-delay applications, the tape loop is like a conveyor belt for information. The tape continually receives data at the record head. Data rides the tape around the loop to the reproduce head and is withdrawn at a predetermined time delay. The interval is determined by length of tape loop and tape speed. Uses are machine and process control, communications memory, and handling of computer data.

The tape-loop recorder also has a talent for repetition. A short loop synchronized with the sweep rate of an oscilloscope provides a repeating signal that makes transient data stand still. For wave analysis, the tape loop reproduces a sample of data repeatedly until it has been scanned for all significant frequencies by a succession of filters. Even a short transient can be analyzed.



The new Ampex FL-100 Tape-Loop Recorder being used with an Ampex FR-100 Reel-to-Reel Recorder. Interchangeable plug-in units make the two compatible with any combination of track characteristics.

For processing or simulation devices, the tape loop provides a program-control cycle of great sensitivity. Tape-controlled repetitions are as identical in pattern as the successive cycles of a mechanical cam – but have advantages of electrical control and infinite variations possible with tape.

Newest of Ampex's tape-loop recorders is the FL-100. It shares the styling and features of Ampex's FR-100 and FR-1100 recorders. The FL-100 uses their same interchangeable plug-in amplifiers, hence each track can be used with any of three recording characteristics. Frequencies from DC to 100,000 cycles can be recorded.

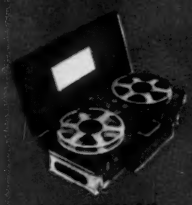
Loop length on the Ampex FL-100 is continually variable from a minimum of 3½ feet up to one of three optional maximums – 25, 50 or 75 feet. Tape widths are quarter, half and one inch. Up to eight tape speeds are available on the same machine. Overall speed ratios can be as high as 128 to 1.

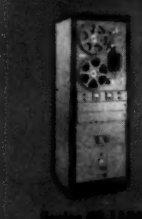
If you would like further information on Ampex's new FL-100 Tape-Loop Recorder – or if you have a special problem to which it is applicable, Ampex's application engineers will be pleased to provide added details. Also, would you like to have this informative ad series mailed to you direct? Write Dept. BB-4.

MAGNETIC TAPE APPLICATIONS BY AMPEX

4

ONE OF A SERIES





INSTRUMENTATION DIVISION

AMPEX CORPORATION

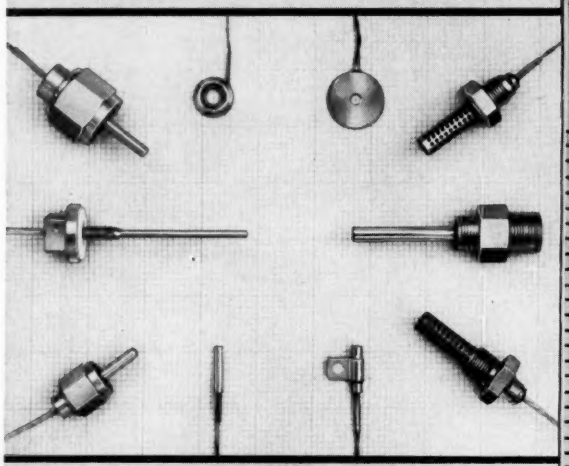
FIRST IN MAGNETIC TAPE INSTRUMENTATION

934 CHARTER STREET • REDWOOD CITY, CALIFORNIA

District offices serving all areas of the United States and Canada; Foreign Representatives in countries around the world.

For more information circle **40** on inquiry card.

For the highest degree of *Accuracy* in AIRBORNE TEMPERATURE INSTRUMENTATION



HIGH OUTPUT • RESISTANCE-TYPE TRANSDUCERS

Arnoux high resistance temperature probes are designed for telemetering and other applications requiring high signal levels. Models are available in a wide variety of physical configurations for measuring surface, fluid, and air temperatures.

- Output up to 5 volts without amplification.
- −320°F to +500°F range with ±2% linearity. (Special units are available up to 1600°F.)
- Nominal resistance values: 100 to 20,000 ohms.
- May be used in AC or DC Bridge circuits.
- Meets MIL-E-5272A specifications.
- Calibration curve supplied with each probe.

When used with ARNOUX miniaturized companion "TME" system, 20K transducers provide 5 volts output for as little as 150°F change.

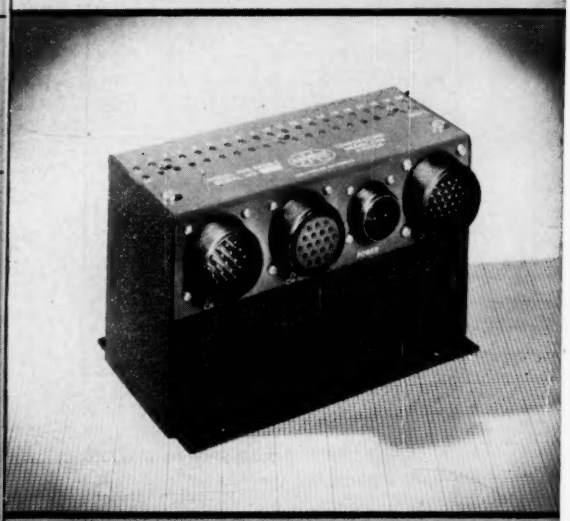
Write for Bulletin 300

MINIATURE MULTI-CHANNEL TEMPERATURE MEASUREMENT SYSTEM . . . full scale output 5 volts

ARNOUX "TME" is a completely self-contained system designed for operation with ARNOUX special resistance-type transducers. Models are offered in 7, 14, and 20 channel capacity. The unit contains two precision mag-amp type, regulated D.C. power supplies, series connected with common neutral, for excitation of the transducers in half bridge circuitry.

- Power requirement: 115 volts, 400 cps.
- Power consumption: 20 channel model requires less than 20 watts.
- Balance and attenuation controls for each channel.
- No vacuum tubes or transistors used.
- Output voltage and impedance characteristics — directly compatible with F.M. sub-carrier and P.W.M. coder input requirements.
- System stability: within 1% throughout MIL-E-5272A environmental.
- Dimensions: 20 channel model: 7" x 4¼" x 3", wt. 5½ lbs.

Write for Bulletin 500



ARNOUX . . . *foremost* in TEMPERATURE MEASUREMENT EQUIPMENT . . . . . TRANSDUCERS, ACCESSORIES AND CUSTOM ENGINEERED SYSTEMS.

ARNOUX CORPORATION

Designers and Manufacturers of Precision Instrumentation

11924 W. WASHINGTON BOULEVARD • LOS ANGELES 66, CALIFORNIA

For more information circle **41** on inquiry card.

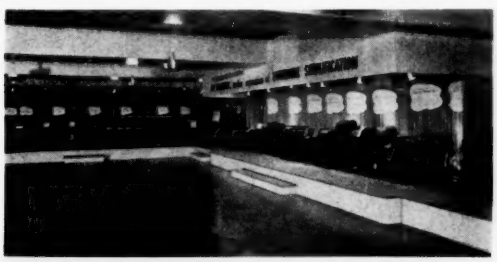
New Plants and Mergers

CONSOLIDATED ELECTRODYNAMICS CORP. has broken ground for two 57,500-sq-ft office, lab., and plant buildings at Monrovia, Calif.

ROBERTSHAW-FULTON CONTROLS CO. has moved its Flexible Shaft Div. to the new plant in Chatham, N. J.

BARBER-COLMAN CO., Wheelco Insts. Div. announces new sub-branch office in Columbus, Ohio.

STANDARD REGISTER CO. announces it has more than doubled its facilities at Dayton, Ohio for its data processing workshop.



FOXBORO CO. will start a 175,000-sq-ft addition to existing plant at Foxboro, Mass., in July.

DUMONT LABS. announces a new coast-to-coast marketing system by independent local distributors.

SERVOMECHANISMS, INC. has laid the corner stone of new million-dollar plant with 55000-sq-ft at Garden City, N. Y.

MAGNETICS INC. announces addition of new control div. with *Dr. Thomas G. Wilson* directing R. and D.

AMPEX CORP. and **ORRADIO INDUSTRIES INC.** are jointly developing instrumentation-type magnetic recording tape.

HOFFMAN ELECTRONICS CORP. has established a new Hoffman Solar Div. in Evanston, Ill.

BECKMAN INSTRUMENTS INC. announces establishment of the new Process Instruments Div. at Fullerton, Calif.

BENDIX AVIATION CORP. announces $5-million plant expansion for its Scintilla Div.

HOW
ANTIQUE
ARE YOUR
MICRO-
MACHINING
METHODS?
PRODUCE SMALL INSTRUMENT PARTS WITH MORE
ACCURACY · ECONOMY and SPEED
ON LEVIN® INSTRUMENT LATHES
For efficiency small work should be done on a small lathe. In many cases the work done on an instrument lathe requires a degree of precision and fine finish which cannot be obtained from larger machines. LEVIN lathes are made in two collet capacities, 5/16" or 3/16", and thirty-three different models. Over 150 sizes of collets available in either capacity. Send for catalog "M" describing complete line of instrument lathes and accessories.
LOUIS LEVIN & SON, INC.—3610 S. BROADWAY—LOS ANGELES 7, CALIFORNIA

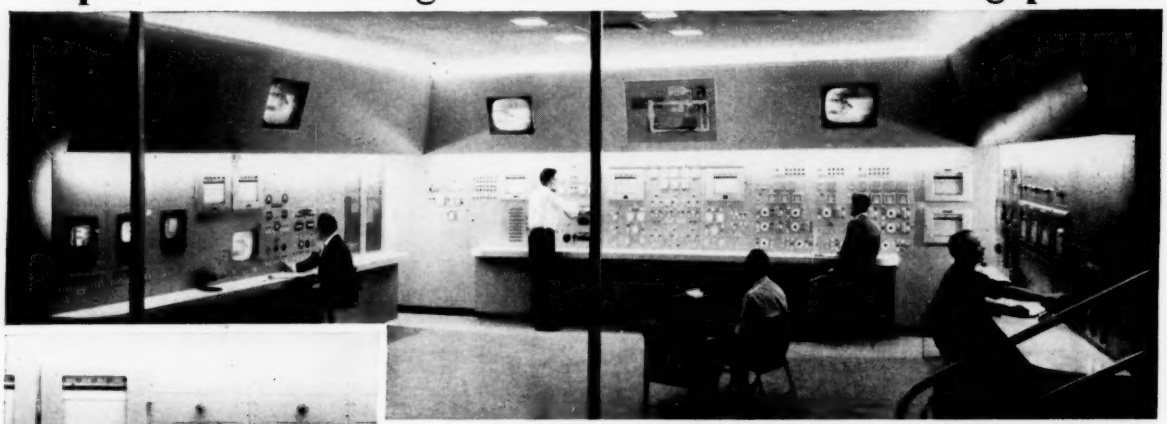
For more information circle **42** on inquiry card.

BRISTOL'S

Instrumentation News

• *News of instrumentation and automatic control in modern industry* •

TV plus instruments give defense scientists the big picture

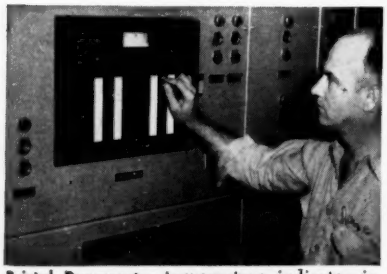


A few of the Bristol instruments in wind tunnel control room at Lewis Flight Propulsion Lab. Over-all view of control room shown at top.

"Complete" is the word for the data aeronautical scientists get here.

This modern supersonic wind tunnel, at the Lewis Flight Propulsion Laboratory of the National Advisory Committee for Aeronautics, Cleveland, Ohio, uses eight TV monitors plus a battery of temperature and strain-gauge scanners to show scientists what's happening to missile models in the wind tunnel. Bristol Dynamaster* electronic recorders, with Gilmore temperature scanning equipment, make permanent records of *up to 300 temperatures* sensed by strategically placed thermocouples on the model and in the tunnel. Other Bristol instruments record the output of strain gauges to show forces acting on the model. Just *one* of the many ways Bristol instruments (and other products) are aiding national defense today.

*T. M. Reg. U.S. Pat. Off.



Bristol Dynamaster temperature indicator in control panel at May Company's North Hollywood department store.

These inconspicuous units—featuring Bristol pencil-type thermocouples—sense temperature at strategic store locations.

Instruments help cool customers, warm sales

Precise control of temperature and humidity pays off in a department store—in customer comfort, employee morale, and in brighter, cleaner merchandise.

That's why the May Company's new store in North Hollywood, California, has installed an air-conditioning control system of the most advanced design. Featuring a precision Bristol Dynamaster multiple-point temperature indicator, it lets operating engineers check the temperature and humidity at strategic store locations at the touch of a button. *What's more, the same set-up allows them to check critical temperatures at 18 locations in the air-conditioning equipment itself.*

BRISTOL'S

Modern techniques like these in instrumentation, automatic control and telemetering yield big dividends today in every industry and in every branch of science and engineering. Find out how to apply them in your field. Write The Bristol Company, 113 Bristol Road, Waterbury 20, Conn.

"HE" shells get precision heat treatment

Casings for high-explosive shells get precise heat treatment before machining, under control of this Bristol system at U.S. Hoffman Machinery Corporation's Scranton, Pa., plant.

This panel, with round-chart Bristol Dynamaster Pyrometers and Bristol Millivoltmeter Pyrometers, is one of several that control the plant's many furnaces of up to three zones each.

6.65

BRISTOL *TRAIL-BLAZERS IN PROCESS AUTOMATION*

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

For more information circle **43** on inquiry card.

little valves cast big shadows

Among Hoke's achievements with small fluid control products is the standard A431 Packless Valve pictured. We hadn't designed it as such, but this valve is one of our contributions in the field of atomic energy. Radiation Counter Labs utilizes this Hoke valve to introduce radioactive samples into their 4 pi Flow Counter. A little radiation goes a long way, and it takes a pretty hot instrument to count the number of atoms disintegrating per second in a sample. Needless to say, leakage would be inexcusable — what with scattering, self-absorption, secondary radiation, inverted gamma rays and other scandalous goings-on making it rough for the atomic scientist. To prevent such problems, this valve is helium leak tested at the brass bellows seal and air tested at the seat (These are routine tests performed on valves in standard production). Helium seat tests are performed when high-pressure is a factor.

There are many other manufacturers like RCL who consider Hoke valves with the same sense of reliability. Sometimes pressure is the important factor . . . or precise control of flow . . . or even simply attractiveness of design. But whatever the application, producers of quality test and production equipment are cognizant of the craftsmanship in Hoke products; and the users of such equipment often look for Hoke valves as assurance of equipment dependability.

Little valves **do** cast big shadows!

HOKE, INCORPORATED, FLUID CONTROL SPECIALISTS, 231 S. DEAN ST., ENGLEWOOD, N. J.

OK

For more information circle **44** on inquiry card.

To 30 g's without a whimper

CEC's DATATAPE FLIGHT RECORDER

First choice for data recording

When you need accurate reproduction of dynamic test data under severe environmental conditions, put a Consolidated DataTape Recorder on the job. This compact instrument will withstand without damage a force of 30 g's for 11 milliseconds along each of the three major axes. It will continue to perform to specifications under a vibrating force of 10 to 55 cps, 0.060" double amplitude, and will withstand steady accelerating forces up to 5 g's in any direction. In Air Force competition tests, the DataTape topped all others in an over-all evaluation. *For complete information, write today for your copy of Bulletin CEC 1561-X24.*

DATA CHANNELS... 12 or 24 standard, plus 1 flutter-control track and 1 time or voice track per 12 data channels.

TAPE SPEEDS... 7½, 10, 15, 20, 30, and 40 in/sec.

RECORDING TIME... 43 minutes at 10 in/sec; 57 minutes at 7½ in/sec.

FLUTTER... less than 0.15% peak-to-peak over 0-to-300-cps band @ 10 in/sec. At 30 in/sec, flutter from 0-to-300 cps will be less than 0.1%. Servo flutter compensation on playback reduces this figure still further; electronic system compensates for flutter at higher frequencies.

POWER... 115 volts, single-phase, 50/60/400 cps; 275 watts.

SIZE... 7 x 22 x 11¾"; 60 pounds.

CONTROLS, INDICATORS... all on top plate.

Consolidated Electrodynamics

300 North Sierra Madre Villa, Pasadena, California

OFFICES IN PRINCIPAL CITIES THROUGHOUT THE WORLD

For more information circle **45** on inquiry card.

TECHNIQUES and DEVELOPMENTS
in oscillographic recording

FROM
SANBORN

RECORDING METHOD USED IN SANBORN DIRECT WRITERS, AND A REVIEW OF THEORETICAL AND ACTUAL ERROR FACTORS

Figure 1 shows the basic scheme by which Sanborn oscillographic recording galvanometers produce graphic records of electrical signal values. If the rapid deflection action of the heated ribbon tip stylus is visualized when current flows in the coil, it can be seen that a straight line at right angles to the chart length is recorded on the chart, at the point where the chart is drawn over a knife edge. The trace, therefore, is a true rectangular co-ordinate graph.

Since this is essentially a process of expressing coil (or stylus) deflection *angles* in terms of *distances* on a chart, the trigonometry of the situation (Fig. 2) must be examined to ascertain the accuracy of the method. Initially, and when θ is small, the tangent and the angle are almost equal numerically. The expression $D = R \tan \theta$ can, therefore, be rewritten $D = R\theta$ (approx.). To the extent this latter expression is true, deflection distances (rather than deflection angles) are an accurate measure of signal values. But to determine the extent of error resulting from using this approximation, the following data have been calculated*, using a chart width of 25 mm either side of zero ("D" in Fig. 2) and effective stylus length of 100 mm ("R" in Fig. 2) in the series expansion for the tangent function. Error as a function of deflection then becomes:

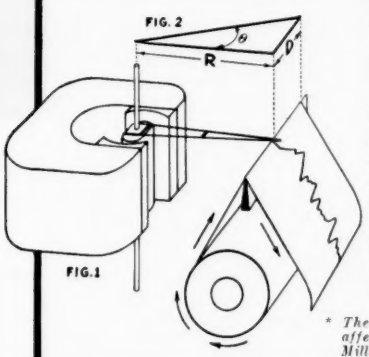


FIG. 1

D mms	Radians	Theoretical Error ϵ	Corrected Error δ	Corrected Error in mms
10	.10	.0033	0	0
15	.15	.0075	.004	.06
20	.20	.0133	.010	.20
25	.25	.0209	.018	.45

When the recording system is calibrated, that calibration is often made on the basis of a one centimeter deflection from the chart center, or by means of a two centimeter deflection starting one centimeter below chart center and finishing one centimeter above chart center. In either case the deflection at one centimeter from chart center is accepted as the standard, and, therefore, is without error. The foregoing table can therefore be corrected by subtracting .0033 from each of the error terms to show the error, δ, to be expected in actual use. The final column in the table shows this error in mms.

Since the active length of the stylus increases as θ increases, deflection D increases more rapidly than θ. All positive error terms in the series expansion bear this out, but the error terms would occur as predicted only if the galvanometer produced deflections exactly proportional to coil currents (that is, ideal spring properties in the torsion rods and uniformity of magnetic field). Pole tips in Sanborn galvanometers are proportioned so that in maximum deflections, galvanometer sensitivity *decreases* slightly, the compensation resulting in *actual* linearity better than that predicted in the table.

* *The mathematics involved here, as well as a discussion of fixed length stylii, design parameters affecting over-all galvanometer performance, etc., are contained in an article by Dr. Arthur Miller "Sanborn Recording Galvanometers", published in the May 1956 Sanborn RIGHT ANGLE. Copies are available on request.*

RECOGNIZE A "150" RECORD

BY THESE *THREE* FEATURES...

1% Linearity

. . . resulting from use of current feedback Driver Amplifier in each channel, high torque galvanometers of new shorted coil frame design. Coil current of 10 ma develops 200,000 dyne cm torque, sensitivity is 10 ma/cm deflection.

Rectangular Coordinates

. . . save analysis time, simplify interpretation and correlation of multichannel records. No waveform curvature, negative time lines, etc.

Permanent Inkless Traces

. . . made by hot nichrome ribbon tip of stylus on heat-sensitive Sanborn Permapaper. Clear, smudge-proof traces that clearly reveal minute signal changes.

Call on Sanborn engineers for help with your oscillographic recording application in the 0-100 cycle range. Descriptive literature is also available on request, providing data on Sanborn 1-, 2-, 4-, 6- and 8-channel Systems, choice of 12 interchangeable plug-in Preamplifiers, Separate and Supplementary Instruments.

SANBORN COMPANY
Industrial Division
175 Wyman Street, Waltham 54, Mass.

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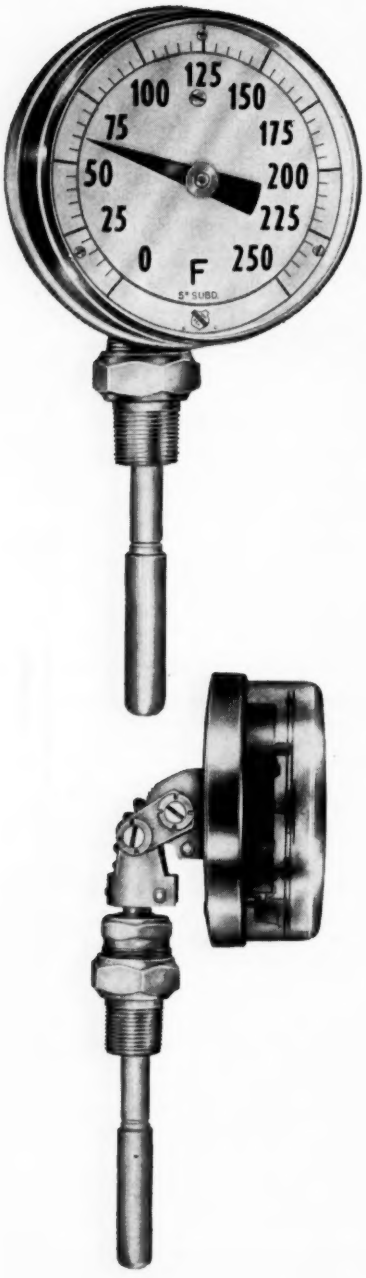

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MERCURY ACTUATION

IN A MODERN 'AMERICAN'

"Every Angle" DIAL THERMOMETER

If you expect the most for your money in readability, accuracy and durability, here is the best dial thermometer investment you can make. The 'American' Mercury-Actuated "Every Angle" Dial Thermometer provides a combination of five major advantages found in no other thermometer:

"Every Angle" Set-ability. You can turn the dial to any angle within 180° on two axes. Whether installed above or below eye level – to the right or left of the reading point – you get easy face-to-face readings.

Fast, Accurate Indication. Mercury – one of the most sensitive heat transfer mediums – makes possible readings up to 1000° F. in a few moments with accuracy within 1% of the entire scale range.

Surest, Sharpest, Easiest Readings. The Maxivision® dial – a split-level dial – is constructed so that the graduations and pointer are on the same plane. No perspective effect. No parallax error in reading.

Best in Visibility. The cover is a large, durable, clear glass dome without bezel. No dark shadows dim the dial to hinder reading accuracy.

Stainless Steel Construction. Movement, capillary tubing, stem, case and cover mounting – all are stainless steel.

Where resistance to corrosion is important, where appearance and cleanliness are essential, the 'American' Mercury-Actuated "Every Angle" Dial Thermometer is ideal. It is rugged – has every quality required for the toughest services, indoors and outdoors. From the standpoint of economy, the "Every Angle" feature alone can save money in new piping specifications and when changing existing piping. It reduces the need to re-specify and stock a variety of fixed stem thermometers.

Dial Size: 4½". *Temperature Ranges:* –20/120° F. to 200/1000° F. *Stem Lengths:* 4", 6", 8", 12", 18" and 24". Separable sockets available.

YOUR INDUSTRIAL SUPPLY DISTRIBUTOR has complete information on the 'American' Mercury-Actuated "Every Angle" Dial Thermometer. Call on him to fulfill your requirements with fast delivery from local stocks.

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People IN THE NEWS

Leroy Score
Daystrom

Cliff Mathewson
Daystrom

Bill Waddell
Daystrom

DAYSTROM SYSTEMS has appointed *Leroy Score* as assistant to the general manager, *Cliff Mathewson* as systems coordinator, and *Bill Waddell* as chief engineer, new products.

HAYS CORP. announces election of *Philip A. Sprague* to president, and *Donald R. Schoen* to executive vice president.

FISCHER & PORTER has promoted *Robert F. Lane* to executive vice president; *Nathaniel Brewer* moves to V. P. in charge of Technology; and *Alexander Greenfield* has been appointed director R. and D.

Don Webster
Librascope

M. D. Shriver
Panellit

R. P. Newcomer
Hagan

LIBRASCOPE has elected *Donald C. Webster* to the position of vice president.

PANELLIT, INC. announces the appointment of *Millard D. Shriver* as vice president—assistant to the president.

HAGAN CHEMICALS & CONTROLS announces that *Robert P. Newcomer, Jr.*, has been named advertising manager.

ASSOCIATED SPRING CORP. announces election of *Owen D. Nee* as treasurer, and *Wallace Barnes* as secretary.

PARKER APPLIANCE CO. announces election of *Col. Franklin C. Wolfe* to the board of directors.

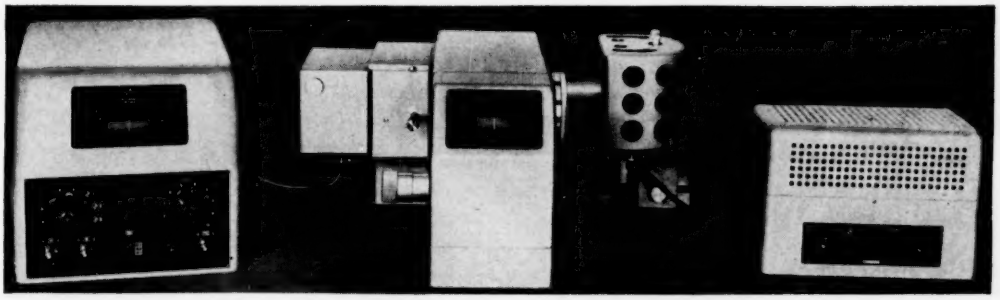
DU MONT LABS has appointed *Daniel Echo* to the newly created post of asst. mgr., Industrial Tube Sales.

U. S. GAUGE announces appointment of *Joseph A. E. Hindman* as sales manager.

CARL ZEISS

SPECTROPHOTOMETER PMQ II

MADE IN WEST GERMANY



- Essential components permit individual use for special research projects.
- Light source and holder for cells widely separated. No temperature influence.
- Direct reading—no compensation method. Rapid location of absorption maxima and minima.
- Repeat settings of smallest slit widths possible due to new design friction-free slit mechanism.
- Projected wave-length and transmittance scales (4 ft.) allow parallax-free reading.
- Built-in chopper diaphragm eliminates dark current and assures strict linearity.
- Adjustable damping device for galvanometer reduces fluctuation at highest amplification.
- Direct operation on 110-volt A.C. No battery necessary.
- Measuring range 200 to 2500 mu.

Write for detailed specifications

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Guaranteed uninterrupted repair service

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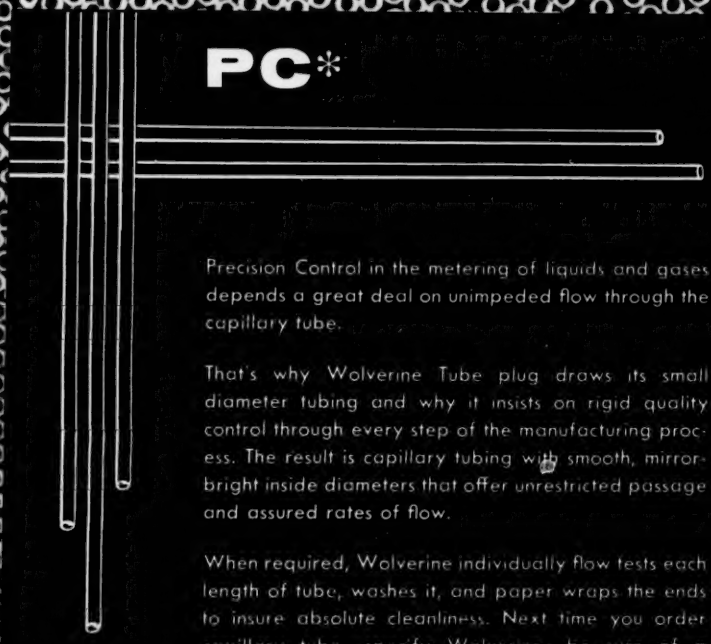
PC*



Precision Control in the metering of liquids and gases depends a great deal on unimpeded flow through the capillary tube.

That's why Wolverine Tube plug draws its small diameter tubing and why it insists on rigid quality control through every step of the manufacturing process. The result is capillary tubing with smooth, mirror-bright inside diameters that offer unrestricted passage and assured rates of flow.

When required, Wolverine individually flow tests each length of tube, washes it, and paper wraps the ends to insure absolute cleanliness. Next time you order capillary tube—specify Wolverine—be sure of a Tubemanship-made product. Write, too, for your free copy of the Wolverine Capilator Book.

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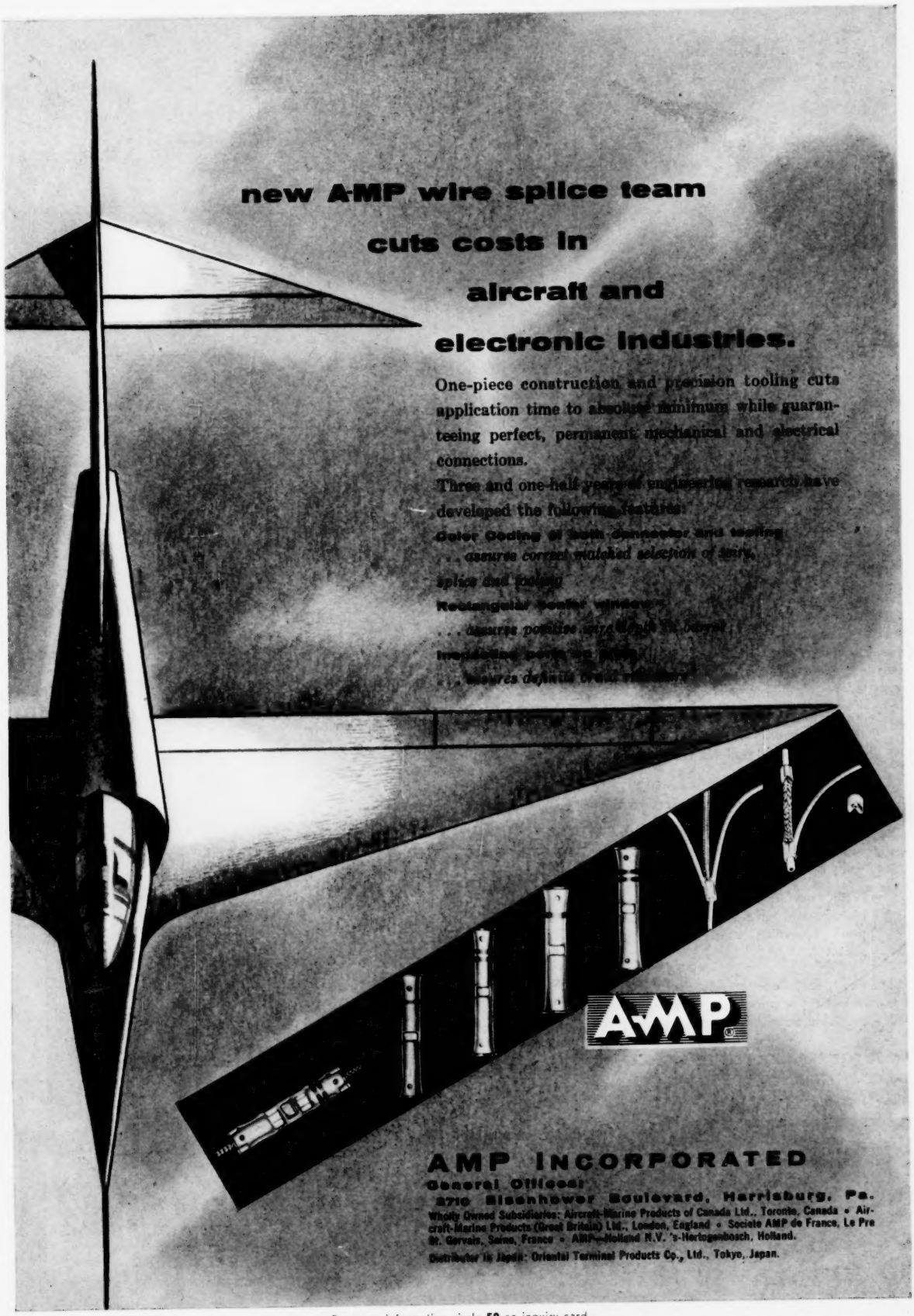
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One-piece construction and precision tooling cuts application time to absolute minimum while guaranteeing perfect, permanent mechanical and electrical connections.
Three and one-half years of engineering research have developed the following features:
Color Coding of both connector and tooling
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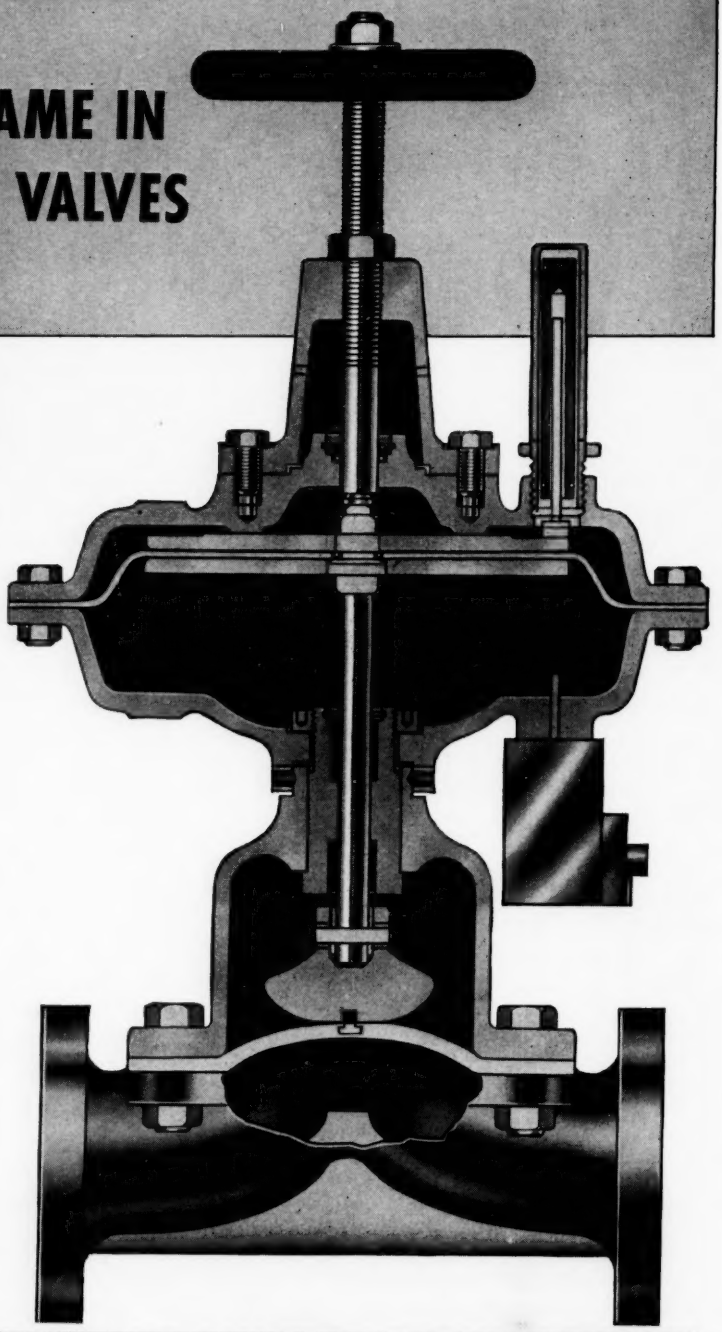
THE FIRST NAME IN AIR OPERATED SAUNDERS VALVES

THOUSANDS IN USE IN LEADING COMPANIES



When you specify Conoflow Air Operated Saunders Valves your confidence is affirmed by thousands of successful installations. Many Conoflow Saunders Valves have been in constant, 24-hour-a-day service, year in, year out, requiring little or no maintenance.

When you specify Conoflow Close-Coupled Saunders Valves you know that you are getting the benefit of more years of experience in this line than any other valve manufacturer can offer. This *extra* engineering "know-how" enables Conoflow to provide:

- Valves in *all sizes* for both *on-off* and *throttling* control—with many original and time-proved optional features.
- Wholly integrated design—*complete valve assembly* made at the Conoflow factory by experienced men.
- Highest quality construction materials —the *right* material for the *right* job.
- Positive performance—every unit *completely tested* for dripless shut-off and peak operating efficiency before shipment.

When you specify Conoflow Saunders Valves you are certain that you are getting the *best* Saunders valve available . . . and at a *competitive price.*

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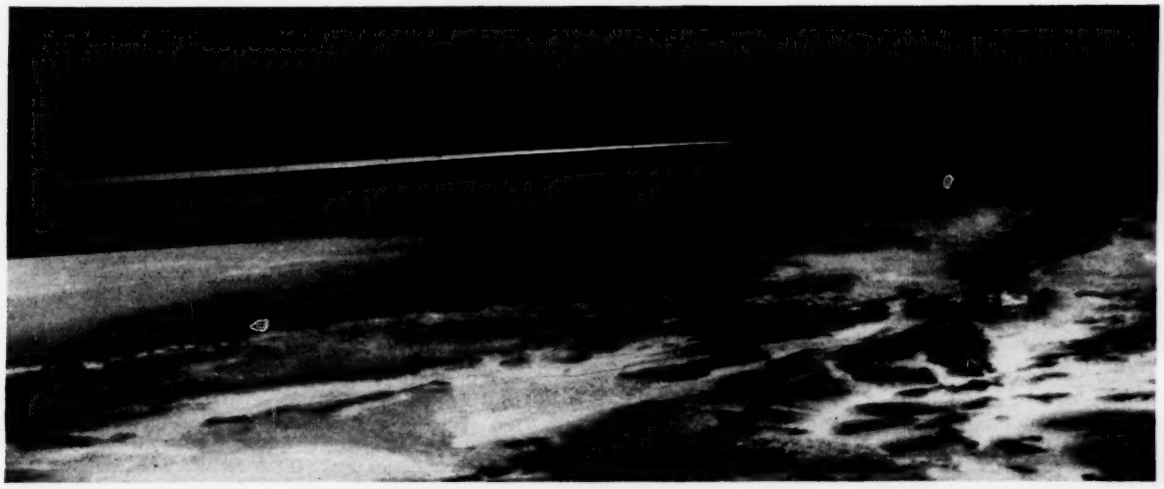
Career News for Engineers!

Flight Tests are under way on one of America's most important defense projects:

The Navaho Strategic Missile



Artwork based on Official U.S. Navy Photograph

The results are secret—but this much can be told. A test vehicle designated the X-10 has gathered new aerodynamic and electronic information which will help to speed progress on the SM-64 Intercontinental Strategic Guided Missile.

The opportunity—and the privilege—to implement this revolutionary data is yours.

Twenty-eight-year-old Army vet **WILLIAM T. SCHLEICH** was graduated from Georgia Tech in 1952 with a BSAE. He joined North American as a junior engineer the same year. Seven months later Bill was promoted to aerodynamics engineer for the Navaho missile program. He was appointed Supervisor, Stability and Control Unit in October of last year. With the help of North American's Educational Refund Plan, he received his MSAE from USC. Bill and his wife are hi-fi enthusiasts and have a sound system built into their Whittier, California home.

If you accept this challenge you'll be solving tomorrow's problems—today. Here facts are collected fresh daily. If yesterday's yield proves inconclusive you'll approach the problem from a new direction. You'll travel new paths and develop new inventiveness. And you'll be guided to each breakthrough by the world's best-informed missile authorities—your own associates.

One example of the new hardware evolving from this creative engineering effort is a fully transistorized electronic commutator. This instrument increases the information-relaying capabilities of the missile's telemetering system by commutating 27 outputs at speeds of approximately 100 cycles per second. It was developed by the Flight Test Instrumentation Group.

North American's Missile Development Division is a major center of missile activity—and a pioneer in the field. As far back as 1948 its first test instrument vehicle was fired from a launching platform. Today North American has complete weapons system responsibility for the Navaho—and its test program is being conducted at the Air Force's long-range missile proving ground which stretches more than 5000 miles across the Caribbean and far into the South Atlantic.

LYLE C. BJORN has lived aviation all of his life. As a high school boy he built a glider modeled after the Wright Bros.' first flying machine—flew it from ski jumps near his Utah home. He studied engineering at Utah State and earned his BSME degree from the U of Wyoming. Lyle joined North American in 1951 and is now Group Leader, Field Test Operations at the Missile Test Facility, Patrick Air Force Base, Florida. He lives with his wife and three children near Cape Canaveral where he is an active leader in Cub Scouts.

If this sounds like the kind of career-opportunity you've been looking for—write us today. We promise you a working climate that stimulates personal growth and rewards it with responsibility, professional recognition and material benefits limited only by your own ability. Further, you can continue to grow academically with the aid of our Educational Refund Plan—and some of the nation's finest universities are nearby.

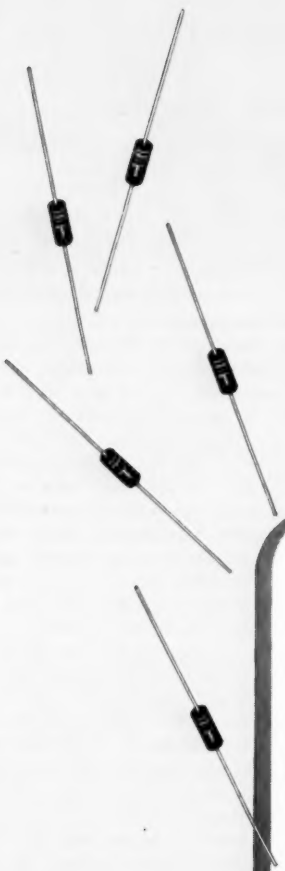
Let us know what kind of creative engineering interests you. (Please include highlights of your education and experience).

CONTACT: Mr. R. L. Cunningham, Engineering Personnel Manager, Dept. 495-IA-6
Missile Development Division, 12214 Lakewood Blvd., Downey, California.

NORTH AMERICAN AVIATION, INC.

Transitron

Fast Switching
SILICON DIODES



Featuring

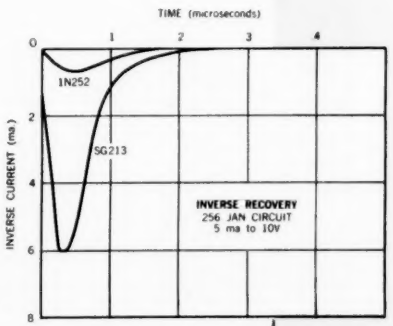
- Recovery times under .3 μs
- High conductance
- High voltage ratings
- Operation to 150° C

Transitron's fast switching silicon diodes are intended for medium and high speed circuits in which diode recovery characteristics are important. These new types are considerably faster in recovery time than other silicon and germanium diodes. They are particularly useful in computer and similar applications.

In addition to excellent static and dynamic properties, reliable performance is assured through close process control and all glass encapsulation.

Type	Minimum Forward Current at 1.5V (ma)	Maximum Inverse Current (μa)	Maximum Inverse Voltage (Volts)	Maximum Recovery Time* (μsec)
SG228	100	.25 @ 175V	200	1
SG226	100	.25 @ 60V	80	1
SG223	30	.25 @ 175V	200	.5
SG221	30	.25 @ 60V	80	.5
SG213	5	.25 @ 175V	200	.3
SG211	5	.25 @ 60V	80	.3
Low Capacitance Types				
1N251	5 @ 1V	.1 @ 10V	30	.15
1N252	10 @ 1V	.1 @ 5V	20	.15

Measured in the 256 – JAN Recovery Circuit



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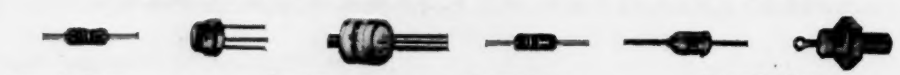

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Ship Displays UNCRATED via North American Padded Vans!

Save time, trouble, expense. Ship your displays—uncrated—via North American *padded* vans! Displays arrive on time; over $1500 worth of protective equipment assures safe "factory-fresh" arrival.

North American service gives door-to-door delivery . . . eliminates local drayage . . . provides storage facilities—and exhibits can be routed from one show to another on fast, tight schedules. Call your local North American agent, or write for Free Display Moving Brochure.

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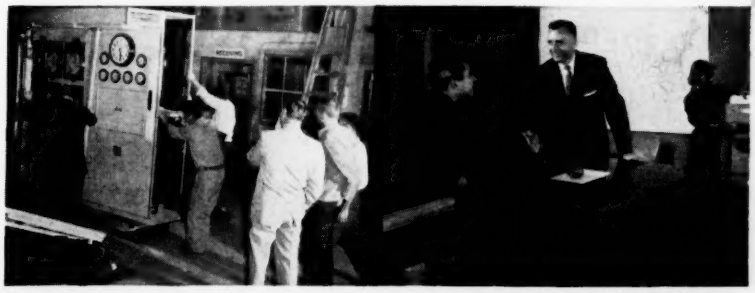
At North American's world headquarters in Fort Wayne, drivers learn to handle exhibits of every size in NAVL padded vans, saving time and money for exhibitors.



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North American Exhibit Display Division assures maintaining of set schedules for touring exhibits, too!

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ANNOUNCING

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You can't beat all-plastic Dekoron Poly-Cor for chemical resistance or for ease of installation. And now, the *new* Dekoron Instrument Tubing Harness adds yet another revolutionary feature—*fire resistance.*

For example, in the direct flame of a cutting torch, it lasted longer than any other multiple-tube harness. Use it in areas where flash fires are a hazard. And *new* Dekoron Instrument Tubing Harness is rugged, too. You can bury it and forget it.

You get all the advantages—chemical, impact and fire resistance—with *new* Dekoron Instrument Tubing Harness. Remember, you can burn it . . . you can bang it . . . you can bury it. And you can *buy it now.* AA-4368

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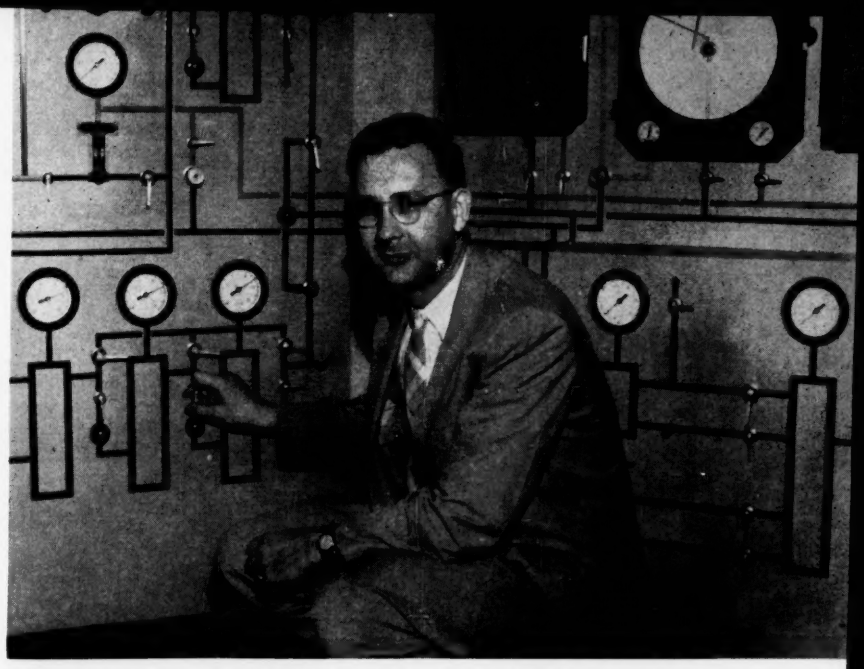
Biographies of significance

SIGNIFICANCE

SIGNIFICANCE of this month's biography is its recognition of an educator who might well be a model of enlightened, progressive education. Otis Updike does a superior job of teaching because he does more than teach. His recent past has been divided between teaching, conducting research and consulting for industry. His drive and enthusiasm for learning have made him outstanding in each direction, primarily due to the competence derived from complementing his participation in any one avenue with the knowledge gained in the other areas.



UPDIKE OPERATES A PNEUMATIC ANALOG SYSTEM designed by Professor Robert M. Hubbard, Head of Chemical Engineering and first Director of the Engineering Experiment Station, for use in the Process Instrumentation courses at the University of Virginia. In addition to graduate courses in process instrumentation taught by Hubbard and Updike, the latter discusses instrumentation in his plant design courses and is now giving a graduate course in machine computation.

DR. OTIS L. UPDIKE

OTIS UPDIKE was born in Roanoke, Virginia, in 1920. He attended the University of Virginia, receiving his B. Ch. E. in 1941. He went on to the University of Illinois for his Ph.D., which he received in Chemical Engineering (with Electronics minor) in 1944. Except for summer work with Eastman Kodak, his first position was chemical engineer with Westvaco Chemical Co., now a division of Food Machinery & Chemical. Here his activities included research and development, pilot-plant operation, and preliminary plant design.

He returned to the University of Virginia in 1946 as Associate Professor of Chemical Engineering, and in 1951 became also a research director with the Engineering Experiment Station of the University. His teaching assignments have included thermodynamics, unit operations, process instrumentation, metallurgy, and plant design. The summers of 1949 and 1950 were spent as an ORINS research participant at the Oak Ridge National Laboratory in the Instrument Department and Reactor Technology. Here he worked on the reactor simulator for the Homogeneous Reactor Experiment (HRE).

By this time he had become very interested in using analog computers for both research and teaching in chemical engineering and, during 1948-1950, he used his spare time to develop a three-component mock-up of a distillation analog-type computer using frequency-modulation techniques. Realizing that the general-purpose analog computer could be applied to many chemical engineering problems Otis studied this field, reading everything he could find on the subject and studying known circuitry and mathematical models. Some undergraduate students with similar interests joined with Otis in their research. Together they built a passive network and an electrolytic-tank analog.

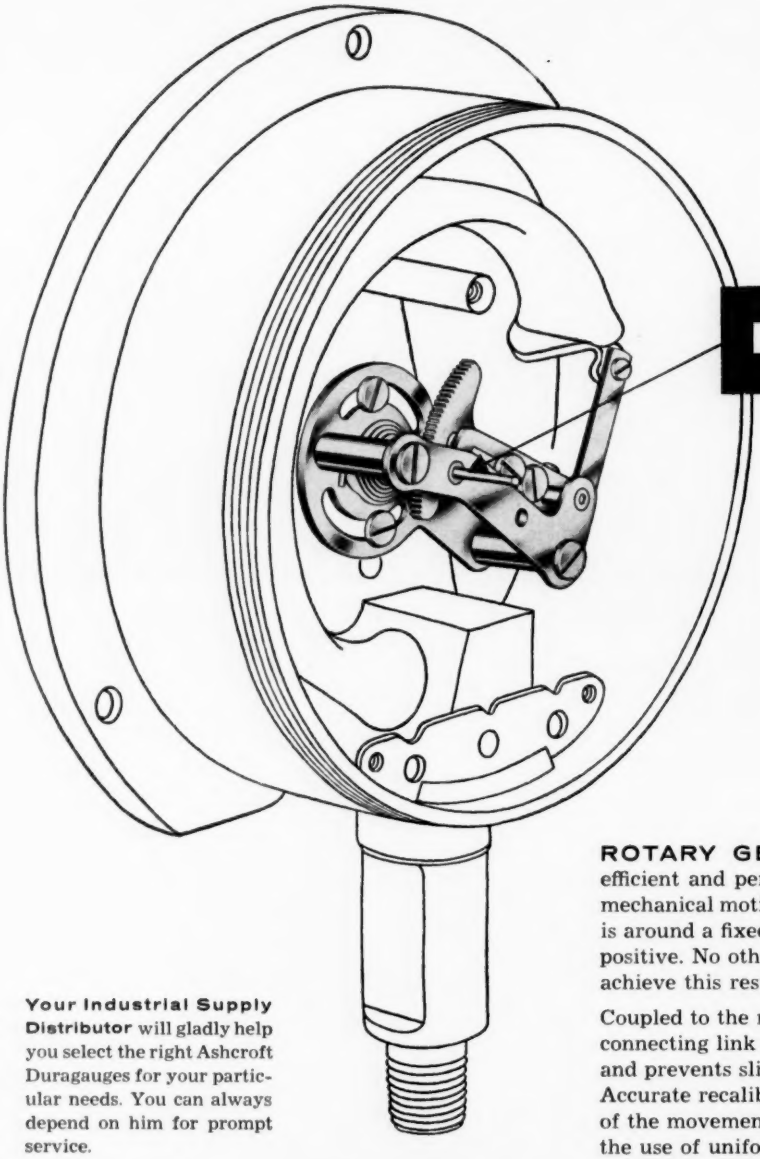
In January, 1952, he received his first *Simulation Council Newsletter*, which John McLeod had mailed to Deans of all schools of engineering, and from which Otis enjoyed learning that many others felt as he did about the implications of analog computers. He inquired into the newborn Simulation Council, found out what they were trying to do, and mailed them $6.00. This brought him the *Newsletter*—a mimeographed sheet of ideas generated and exchanged at their meetings. (The next year he saved his $6.00 by helping Stan Rogers design the emblem of the Simulation Council.)

Inquire, learn, do, and teach was the productive cycle for Otis in these first years of this decade. Summers were spent in full-time Experiment Station research. In 1954 he received leave to go to Pt. Mugu as Technical Consultant with the Naval Air Missile Test Center, doing functional simulation. This gave valuable, practical substance to the simulation background he had been developing at the University's Experiment Station. The 1954-55 session was spent with NAMTC at Mugu, working with John McLeod and his group (for the first half of 1955 he was steering committee chairman of the Western Simulation Council).

He returned to the University in 1955 and is now working on problems in heat exchange, nuclear reactions, and a variety of process problems including liquid-liquid extraction and reaction kinetics. He is also vice president of Jefferson Research Laboratories, a small but growing organization specializing in instrument development for industry. He also is active in the Eastern Simulation Council and is on the Steering Committee for 1957.

Otis Updike typifies the progressive educator. He not only keeps abreast of his field, but has pushed its frontiers with his own research.

Continued on page 1075



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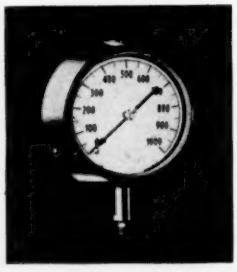
ROTARY GEARED MOTION, the most efficient and perfect method of transmitting mechanical motion ever developed. Because rotation is around a fixed center, pointer position is always positive. No other type of movement can ever achieve this result.

Coupled to the movement is a one-piece connecting link that guarantees correct calibration and prevents slippage or parting under tension. Accurate recalibration is easy from front or rear of the movement. Universal adjustability permits the use of uniformly graduated dials, thereby facilitating maintenance.

The Ashcroft Duragauge is available with all-stainless-steel movement or stainless steel with nylon bearings and pinion gear. There are case designs and materials, Bourdon tube materials, pressure ranges and dial sizes to meet your service conditions exactly. Save time, trouble and money. Specify the pressure gauges of highest sustained accuracy and durability – Ashcroft Duragauges.

Your Industrial Supply Distributor will gladly help you select the right Ashcroft Duragauges for your particular needs. You can always depend on him for prompt service.



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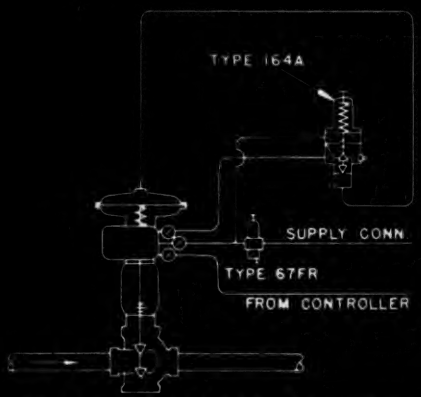
MAKERS OF 'AMERICAN' INDUSTRIAL INSTRUMENTS, 'CONSOLIDATED' SAFETY AND RELIEF VALVES, 'AMERICAN-MICROSEN' INDUSTRIAL ELECTRONIC INSTRUMENTS, *Stratford, Conn.* 'HANCOCK' VALVES, *Watertown, Mass.* 'CONSOLIDATED' SAFETY RELIEF VALVES, *Tulsa, Oklahoma.* AIRCRAFT CONTROL PRODUCTS, *Danbury & Stratford, Conn. and Inglewood, Calif.* "SHAW-BOX" AND 'LOAD LIFTER' CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES, *Muskegon, Mich.*

For more information circle **55** on inquiry card.

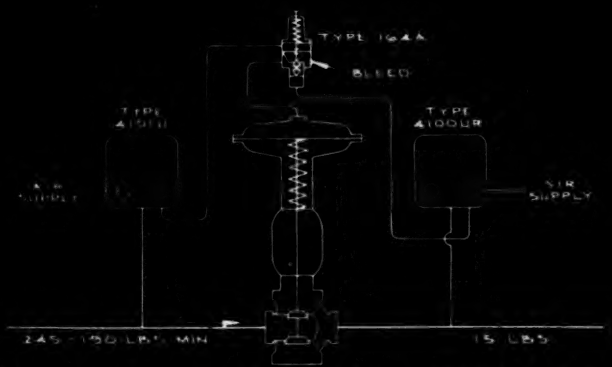
Circle **56** on inquiry card.→

FISHER® SERIES 164

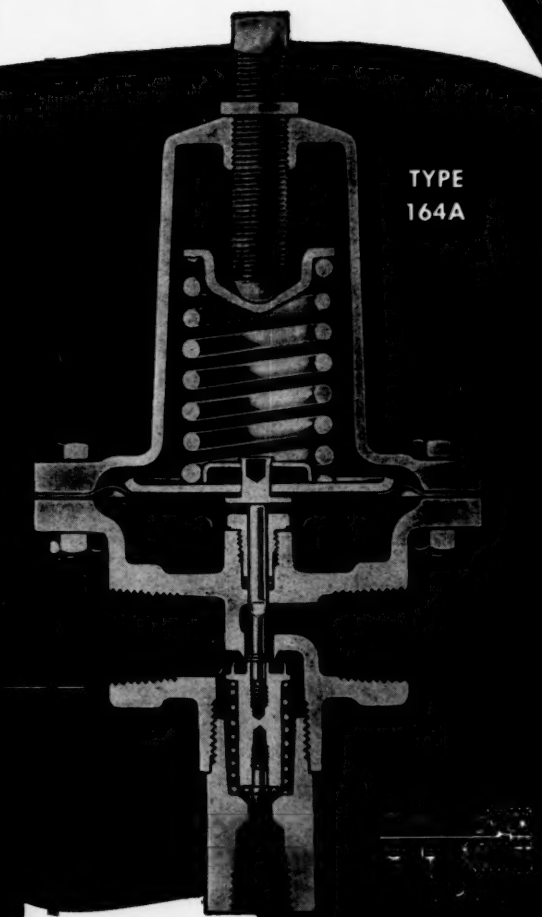
For "Gadgeteering" Control SUCH AS



Lock up system using Type 164A to close air circuit to diaphragm of main valve in case of plant air failure. Main valve will be held in position at time of supply pressure failure.



Pressure reduction normally handled by 4100UR Wizard. If inlet pressure to main valve falls below a predetermined amount Type 4101U snap-acting Wizard bleeds pressure off Type 164A switching valve causing 3-way valve to change position so as to close control line pressure and bleed main valve diaphragm pressure to atmosphere. Main valve will stay closed until inlet pressure is restored to desired amount.



- SMALL
- COMPACT
- SELF CONTAINED

Side view of Type 164 Showing ¼" Control Line Connection. Control Chamber is separate from body chamber.

SIZES ¼" or ½"

CONTROL SPRING RANGES PSI	PRESSURE CHANGE ON DIAPHRAGM FOR FULL VALVE STROKE PSI
3 to 15	2
5 to 20	2½
5 to 35	4
30 to 60	5¾

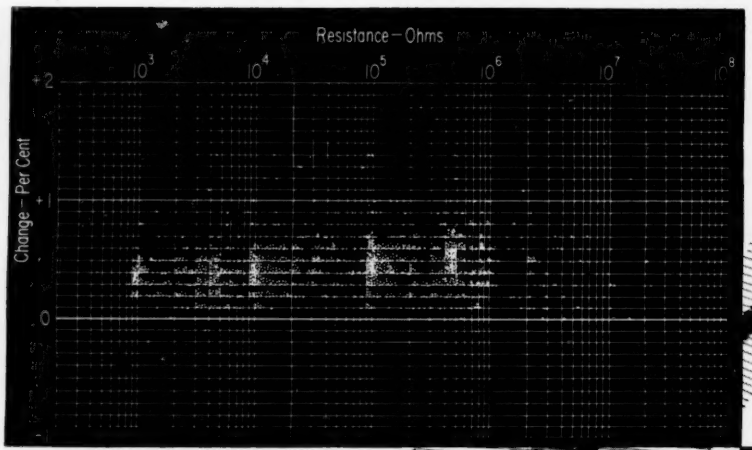
MATERIALS

Zinc die cast body and spring case, composition diaphragm and valve disc.

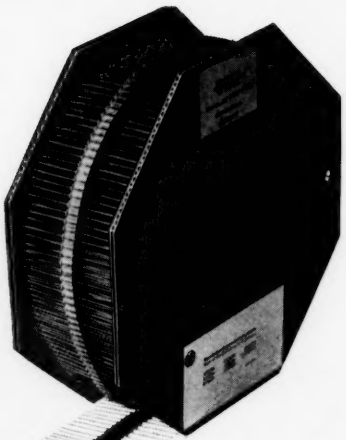
FISHER GOVERNOR COMPANY
MARSHALLTOWN, IOWA
CANADIAN PLANT: WOODSTOCK, ONTARIO
WORLD LEADER IN RESEARCH FOR BETTER PRESSURE AND LIQUID LEVEL CONTROL

they look alike...

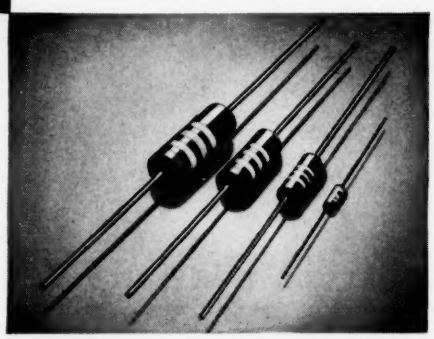
and they are alike!



Average resistance change (%) after temperature tests (5 cycles from -55°C to 85°C) on samples from over *two billion* Allen-Bradley ½ watt resistors.



Allen-Bradley fixed resistors are available in 1/10, ½, 1, and 2 watt sizes, in all standard RETMA resistance values.



ALLEN-BRADLEY
molded composition RESISTORS

They look as alike as peas in a pod—but actually they are *far more* uniform! Resistance readings taken before and after five complete cycles from -55°C to 85°C showed an average resistance change of about ½ of 1%. The maximum resistance change—as indicated on the chart—was below 2%, with the majority of the units registering below 1% change. The chart is a six year record—covering 1248 tests of samples from production runs totaling over two billion resistors. This is only one of many tests to which Allen-Bradley resistors are subjected—to keep "tab" on their quality and uniformity.

This uniformity and stability is the reason that Allen-Bradley fixed resistors are the *quality* standard of the electronics industry.

Allen-Bradley Co., 140 W. Greenfield Ave., Milwaukee 4, Wis.
In Canada—Allen-Bradley Canada Limited, Galt, Ont.

ALLEN-BRADLEY.

RADIO, ELECTRONIC, AND TELEVISION COMPONENTS

For more information circle **57** on inquiry card.

BIOGRAPHIES

Continued from page 1071

He tests his own theories by accepting practical, responsible assignments, then brings this tested knowledge back to the classroom. His advice to teachers and students is, "Read the magazines of your field, conference papers in your subject, and keep abreast of meetings and technical society activities. This is what I tell my own students in process instrumentation. I don't miss a month of *I&A;* of course, the *Simulation Council Newsletter* is the first section to which I turn. I'm rather proud that we now have six Councils and are even an international group."

"The arrangement whereby *I&A* carries the SC/NL seems a natural to me. I had found *I&A* valuable for some time, and had long thought in terms of greater applications of computers (all kinds) in the process industries. Our technology has too many convenient divisions that tend to confine engineers within little areas of specialization. I'm a believer in opening as many gates as possible between the different pastures; this is a good way to make all the groups more productive. *Instruments and Automation* is doing technology a far greater service in carrying the *Newsletter* than if it were channeled into a journal for computer specialists."

"Incidentally, some of the ivory-tower computer folk ought to gain from the general industrial coverage —both editorial and advertising—of *I&A*. The symbiosis should be fruitful!"

In addition to his Ph.D, Otis acquired a Mrs. from Illinois. He married Mary Wand in 1946, and a visible (and audible) result is four girls that now range in age from two to ten. The family enjoy new places and new foods, travel, and camping-out together.

One corner of their living room is generally filled with components and chassis, evidence of interests in audio and amateur gear. His ham call is W4LAM, but what time he can find to use it goes into experimenting more than on-the-air operation.

Otis isn't planning on retiring just yet—a general-purpose analog facility is going into service at the University this summer and there is even a longer-range prospect of some digital equipment. With the Experiment Station activity and a nuclear reactor approved for construction, there should be plenty of "live" problems at Virginia for both research and teaching.

HAGEN
Synchronous motors

most powerful for its size

Laminated rotor construction of the Model 50 Hagen Motor produces exceptionally high torque. For example, the rotor develops 10 ounce inches torque at 4 RPM. This motor is ideal for those applications requiring from 5 to 10 times the power of clock-type miniature motors. Yet in spite of its power, the motor is extremely compact:

DIMENSIONS

	50 to 60 cycle	25 cycle
A	3-3/32	3-1/16
B	1-13/32	1-23/32

Just a few of the many possibilities for use are: door chimes, laundry timers, depth finders, animated displays, heating controls, program clocks, fire alarm systems, integrators, time switches, chart drives, scoreboards, potentiometer drives. Motor may be mounted in any position. Wide selection of output speeds from 1800 to 1/6th RPM. Reversible and other models available. Send coupon for Bulletin No. 1055.

MAIL COUPON TODAY

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Dept. IA-657, Moline, Illinois

Please send Bulletin 1055 on Hagen Synchronous Motors.

NAME AND TITLE

COMPANY

ADDRESS

CITY ZONE STATE

For more information circle **58** on inquiry card.

THE ONE UNIVERSAL METER

MICROVOLTS TO KILOVOLT

The **KIN TEL** Model **203** is a combination DC microvolt-ammeter and amplifier. It provides an exceptionally wide range of measurements. Fifteen voltage ranges cover from 100 microvolts full scale to 1000 volts full scale, with 100 megohms input impedance. Ten current ranges cover from 100 micro-microamperes full scale to 100 milliamperes full scale. As little as 10 microvolts or 10 micro-microamperes may be measured with accuracy. The uncluttered zero-center meter face instantly indicates polarity on a mirrored scale. When used as a DC amplifier, the instrument features exceptionally low drift with high gain, very high input impedance and low output impedance. Gains up to 80 db with less than 10 microvolts drift may be obtained. The Model **203** utilizes **KIN TEL'S** unique chopper stabilized circuit to provide high sensitivity with previously unobtainable drift-free stability and high input impedance.

APPLICATIONS: Electronic, medical, geophysical, chemical, metallurgical research and development . . . transistor production and circuit design . . . thermocouple calibration . . . null detector . . . recorder driver amplifier . . . and as a general purpose laboratory instrument wherever dc voltage and currents are measured or amplified.

SPECIFICATIONS

Voltage Range (full scale)	100μv to 1000v
Current Range (full scale)	100μμa to 100 ma
Input Impedance	10 megohms below 10 mv, 30 megohms at 30mv, 100 megohms above 30mv
Impedance Accuracy	±1.5%
Accuracy on All Ranges	±3% of full scale
Maximum Gain as Amplifier	80 db ±1.5%
Output Rating	1v across 1000Ω
Output Impedance	less than 5Ω
Drift (after 15 min. warmup)	10μv equivalent input
Price	$550.00

Rack Mounting available as Model 203R

KIN TEL
[KAY LAB]

STABILITY *locked in!*
WITH CHOPPER AMPLIFIERS

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For more information circle **59** on inquiry card.

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VARIABLE TRANSFORMERS for HIGH FREQUENCY APPLICATIONS

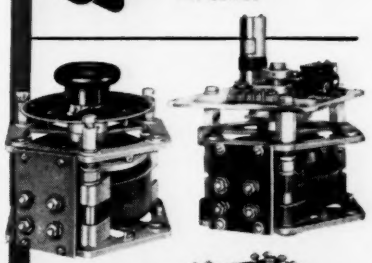
HS SERIES

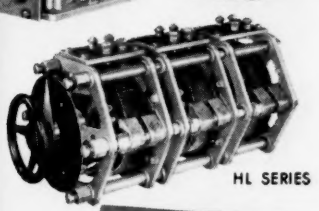
— ⅓ the weight — ½ the size of 60 cycle units

Designed for use in high frequency control systems where weight and space must be minimized, these POWERSTATS are ideal for ship, aircraft, guided missile and other 400/800 cycle applications.

Listed are some of the standard line of POWERSTATS for high frequency applications. However, many high frequency requirements necessitate designing to individual needs. The Superior Electric Company will be pleased to work with you on the design of POWERSTATS to satisfy new or unusual needs.

HM SERIES





HL SERIES

INPUT		OUTPUT				MANUALLY-OPERATED MODELS				MOTOR-DRIVEN MODELS				
VOLTS	FREQUENCY CYCLES PER SECOND	VOLTS	MAXIMUM AMPERES	MAXIMUM KVA	TYPE OF CONSTRUCTION	TYPE	METHOD OF TURNING	APPROX. WEIGHT (POUNDS) NET	APPROX. WEIGHT (POUNDS) SHIPPING	TYPE	STANDARD MOTOR-DRIVES	SPEED OF TRAVEL IN SECONDS	APPROX. WEIGHT (POUNDS) NET	APPROX. WEIGHT (POUNDS) SHIPPING
SINGLE PHASE														
28	400/800	0–28	2.0	.056	Open	3HS02UK	Knob	0.5	0.9					
28	400/800	0–28	4.0	.112	Open	3HS04UK	Knob	0.8	1.2					
120	400/800	0–120 or 0–140	1.0	.14	Open	1HS01UK	Knob	0.9	1.3					
120	400/800	0–28	2.6	.073	Open	1RHS03UK	Knob	0.6	1.0					
120	400/800	0–120 or 0–140	3.0	.42	Open Square Frame	1HMS03UK	Knob	2.4	2.8	DM1HMS03U	28 Volt D-C	60	4.5	5.1
										AM1HMS03U	120 Volt A-C, 400 Cycles	60	4.5	5.1
120	400/800	0–120 or 0–140	7.5	1.0	Open Square Frame	1HMS07UK	Knob	3.4	3.8	DM1HMS07U	28 Volt D-C	60	5.5	6.1
										AM1HMS07U	120 Volt A-C, 400 Cycles	60	5.5	6.1
120	400/800	0–120 or 0–140	15.0	2.1	Open	1HL15UK	Knob	11.4	14.0	DM1HL15U	28 Volt D-C	60	13.2	16.2
										AM1HL15U	120 Volt A-C, 400 Cycles	60	13.2	16.2
240	400/800	0–240 or 0–280	3.0	.84	Open Square Frame	2HMS03UK	Knob	3.4	3.8	DM2HMS03U	28 Volt D-C	60	5.5	6.1
										AM2HMS03U	120 Volt A-C, 400 Cycles	60	5.5	6.1
240	400/800	0–240 or 0–280	9.0	2.5	Open	2HL09UK	Knob	12.8	15.4	DM2HL09U	28 Volt D-C	60	14.6	17.6
										AM2HL09U	120 Volt A-C, 400 Cycles	60	14.6	17.6
THREE PHASE														
240	400/800	0–240 or 0–280	3.0	1.5	Open	2HMS03UK-3Y	Knob	7.6	8.5	DM2HMS03U-3Y	28 Volt D-C	60	9.3	10.5
										AM2HMS03U-3Y	120 Volt A-C, 400 Cycles	60	9.3	10.5
240	400/800	0–240 or 0–280	7.5	3.6	Open	2HMS07UK-3Y	Knob	10.6	11.6	DM2HMS07U-3Y	28 Volt D-C	60	12.3	13.6
										AM2HMS07U-3Y	120 Volt A-C, 400 Cycles	60	12.3	13.6
240	400/800	0–240 or 0–280	15.0	7.3	Open	2HL15UK-3Y	Knob	34.5	41.0	DM2HL15U-3Y	28 Volt D-C	60	38.0	45.0
										AM2HL15U-3Y	120 Volt A-C, 400 Cycles	60	38.0	45.0
480	400/800	0–480 or 0–560	3.0	2.9	Open	4HMS03UK-3Y	Knob	10.6	11.6	DM4HMS03U-3Y	28 Volt D-C	60	12.3	13.6
										AM4HMS03U-3Y	120 Volt A-C, 400 Cycles	60	12.3	13.6
480	400/800	0–480 or 0–560	9.0	8.7	Open	4HL09UK-3Y	Knob	39.0	45.5	DM4HL09U-3Y	28 Volt D-C	60	42.5	49.5
										AM4HL09U-3Y	120 Volt A-C, 400 Cycles	60	42.5	49.5

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THE SUPERIOR ELECTRIC COMPANY

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Company.....

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PROBLEM:

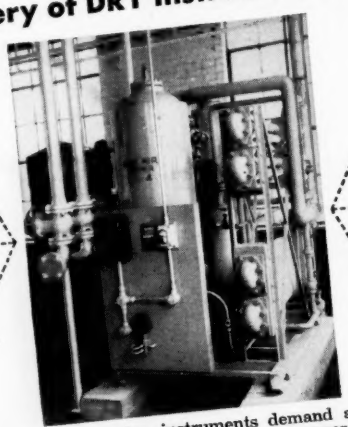
Moisture in instrument air lines causing control trouble, corrosion and freeze-ups in cold weather!

ASSIGNMENT: Find a low-cost, dependable means of getting DRY air!

SOLUTION:

Pritchard **HYDRYER**®

Unmatched for Continuous Delivery of DRY Instrument Air!



Precision automation instruments demand a constant source of extremely dry air for accurate operation. The Pritchard HYDRYER has proved its ability to deliver air that is free from damaging moisture. Only in a Pritchard HYDRYER do you get all of these features:

- NO WASTE — 100% of all air or gas entering the HYDRYER is dried without loss.
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- LONGER ADSORBENT LIFE.
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Kansas City, Missouri

For more information circle **61** on inquiry card.

Events

June 27-July 1

British I. R. E. Convention of Electronics in Automation, University of Cambridge, London, England. For information write British Institution of Radio Engineers, 9 Bedford Square, London, W. C. 1, England.

August 20-23

Western Electronic Show and Convention, Cow Palace, San Francisco, Calif. For information write Western Electronic Show and Convention, 342 N. La Brea Ave., Los Angeles 36, Calif.

August 26-30

Eighth Annual Infrared Spectroscopy Institute, Fisk University, Nashville 8, Tenn. For information write Nelson Fuson, Infrared Spectroscopy Institute, Fisk Univ., Nashville, Tenn.

August 28-30

National Gas Chromatography Conference, Michigan State University, Kellogg Center, E. Lansing, Mich. For information write I.S.A., 313 6th Ave., Pittsburgh, Pa.

September 4-6

Magnetic Amplifiers Conference of the Institute of Radio Engineers-American and the Institute of Electrical Engineers, Penn Sheraton Hotel, Pittsburgh, Pa. For information write AIEE, 33 W. 39th St., N. Y. 18, N. Y.

September 9-13

12th Annual ISA Conference & Exhibit, Auditorium, Cleveland, Ohio. For information write William Kushnick, 313 Sixth Ave., Pittsburgh 22, Pa.

September 23-25

6th Annual Meeting of the Standards Engineers Society, Hotel Commodore, New York, N. Y. For information write Standards Engineers Society, Box 281, Camden 1, N. J.

September 24-25

Industrial Electronics Conference, sponsored by the Institute of Radio Engineers and American Institute of Electrical Engineers, Morrison Hotel, Chicago, Ill. For information write A.I.E.E., 33 W. 39th St., New York 18, N. Y.

October 10

Reliability and Quality Control in Electronics conference of the A.I.E.E., Silver Springs, Md. For information write A.I.E.E., 33 W. 39th St., New York 18, N. Y.

October 17-18

National Conference on Industrial Hydraulics, Sherman Hotel, Chicago, Ill. For information write Armour Research Foundation, Illinois Institute of Technology, 10 W. 35th St., Chicago 16, Ill.

October 24-25

Computer Applications Symposium, Sherman Hotel, Chicago, Ill. For information write Armour Research Foundation, Illinois Institute of Technology, 10 W. 35th St., Chicago 16, Ill.

November 2-10

INTERKAMA (International Congress and Exhibition of Measuring Instrumentation and Automation), Dusseldorf, Germany. For information write Nordwestdeutsche Ausstellungs-Gesellschaft m. b. H., Ehrenhof 4, Dusseldorf, West Germany.

November 6-8

I.R.E. 1957 Aero-Com Symposium, Hotel Utica, Utica, N. Y. For information write R.A. Zachary, Vice Chairman for Technical Program, 11 Arbor Drive, New Hartford, N. Y.

November 7-8

Louisiana Polytechnic Institute 6th Annual Instrumentation Conference, Louisiana Polytechnic Institute, Ruston, La.

November 11-13

Instrumentation Conference and Exhibit, Institute of Radio Engineers, Biltmore Hotel, Atlanta, Ga. For information write B. J. Dacher, School of Electrical Engineering, Georgia Institute of Technology, Atlanta, Ga.

December 9-12

1957 Eastern Joint Computer Conference and Exhibit, Sheraton Park Hotel, Washington, D. C. This conference will be sponsored by the Institute of Radio Engineers, the Association for Computing Machinery and the American Institute of Electrical Engineers.

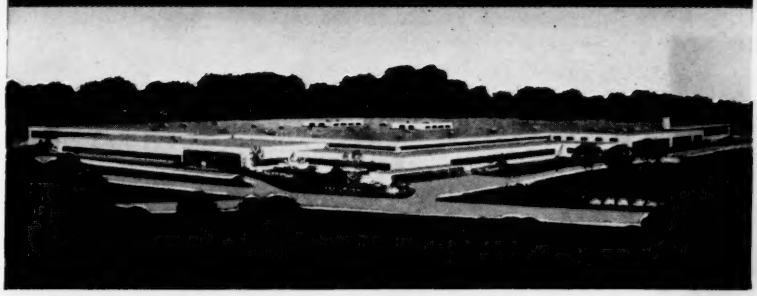
May 31-June 8, 1958

European Congress of Chemical Engineering and ACHEMA Congress, Frankfurt a.M., Germany. For information write DECHEMA, Dechema-Haus, Rheingau-Allee 25, Frankfurt a.m., West Germany.

June 9-13, 1958

Fourth International Automation Exposition, Congress, Conferences, and Clinics, New York Coliseum. For information write Richard Rimbach Associates, 845 Ridge Ave., Pittsburgh 12, Pa.

Production News from Bridgeport Thermostat



FROM THIS ALL-NEW PLANT— MORE AND BETTER BELLOWS

On its new 15-acre site at Milford, Conn., Bridgeport Thermostat now has 180,000 square feet of automated production facilities to assure quick delivery of all the bellows or bellows assemblies you need . . . at the lowest possible cost. A temperature and humidity controlled room for charging bellows assemblies is only one of the many ways in which this ultra-modern plant promises you bellows assemblies of consistently high quality.

¼" DIAMETER BELLOWS

Progress at Bridgeport is typified by this tiny bellows for miniaturization. Available in seamless design with a wide range of characteristics in brass, phosphor bronze, beryllium copper and monel. Larger sizes available.

Robertshaw-Fulton CONTROLS COMPANY

BRIDGEPORT THERMOSTAT DIVISION • MILFORD, CONN.

Please send me the following information: Dept. LL-125

☐ Full details on small-diameter bellows.

☐ Bellows Engineering Bulletin.

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COMPANY_____

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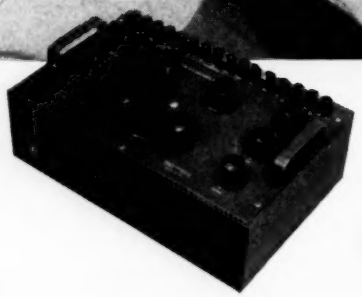
CITY_____ ZONE_____ STATE_____

For more information circle **62** on inquiry card.



New Type K-3 Potentiometer keeps Melpar's radar test gear "on the beam"

Obtaining a high electrical accuracy is vital when designing and producing radar and fire control devices, analog and digital computers, etc. Melpar Inc. at Falls Church, Va., a subsidiary of Westinghouse Air Brake Co., relies on L&N's Type K-3 Universal Potentiometer as the prime d-c measuring instrument for their entire plant. The K-3 inter-compares standard cells calibrated by the National Bureau of Standards. Then, using these cells as reference, it calibrates the accuracy of voltmeters, ammeters and wattmeters used throughout the plant to check this complex electronic equipment.

This heavy workload of checking standards and instruments is easily handled by the K-3 because, as the head of the Quality Control Laboratory at Melpar says, its new design and convenience features permit "faster readings . . . and human errors are avoided because of the K-3's central reading window and decimal point indication of range. It is also much easier to standardize."

With these features, plus others such as the instrument's guarding against static and leakage, its built-in auxiliary potentiometer, etc., this Type K-3 will give you more accurate emf measurements in less time. Why not investigate the possibilities of this advanced potentiometer today. Write for the six-page Data Sheet E-51(6) on the K-3 from Leeds & Northrup Company, 4955 Stenton Ave., Philadelphia 44, Pa.

LEEDS & NORTHRUP
Instruments — Automatic Controls • Furnaces

For more information circle **63** on inquiry card.

INSTRUMENTS and AUTOMATION

Editorial

AUTOMATION: The use of devices—mechanical, pneumatic, hydraulic, electrical and electronic—for making automatic decisions and efforts.—*M. H. Aronson*, Editor

REPORT OF THE PRESIDENT*

to the 39th Annual Meeting of the Scientific Apparatus Makers of America

As I complete my second year and come to the termination of my incumbency as your president, I feel that some words from the president will be beneficial in the coordination of Association and Section activity.

While it is true that the general direction of the Association is provided by the Board of Directors, and that policies and programs are essentially thrashed out by the Board, the Executive Committees of the Sections or the members themselves in Committees, I am sure that we wouldn't get to first base in the operation of this Association were it not for our fine Staff. Each president, including myself, comes to realize how much we depend upon the effective services of *Ken Andersen, Hamp Auld, Bill Stevenson, Jim Irving, Florence Saum* and the other ladies of the office organization as they go about the multitude of details necessary for a smooth-running association.

Market Statistics

During the past few years the economic environment of this country has provided an exceptional market climate for all of us to operate in. Today's increasing dependence upon technology brings about a corresponding dependence upon the industrial and scientific instruments our members produce.

Regardless of what set of statistics you study—SAMA's, the Department of Commerce reports, the various analyses by the business and technical journals, or the '54 Census of Manufactures released last year—one thing is common to all. They are "imposingly bullish," and charged with vigor.

Although the Census gave us the first collated information in seven years on the control industry, an assay of this data still doesn't give an all-encompassing view of the instrumentation and scientific instrument industry. There is much mismatching in the various categories which can only result in a confused and incomplete picture. There is no one source clearly defining the economic progress of our industry. Yet, if you are statistically inclined, there are reliable sources which dramatize the growth of our industry by predicting industry sales of $3.4 billion by 1960 and on up to a whopping $6 billion by 1965! Of course, such figures include a lot of military gear not strictly instruments as we use the term. However, no matter what you do in discounting such figures, there seems clear evidence that we can look for high levels of activity in our industry.

Our own SAMA studies reflect a 6 to 40 per cent sales increase in 1956, and prospects for 1957 look favorable to continue these levels or to even exceed them.

The difficulty of developing a realistic picture of our industry is known to all of us who have tried to get good data. It is an almost impossible task to define our industry and then sub-divide it such that governmental census or data-gathering agencies could collect really dependable and comprehensive data. It is, as I see it, beyond any private effort. Nate Golden's division of B.D.S.A. may one day be the source of such valuable data through the classification work he is doing with the help of his Deputies.

Favorable Market Factors

One of my personal favorites among the statistics available to us as businessmen is the data on *planned capital expenditures.* When industry is actively building new plant or modernizing the old; when depreciation throw-off in industry is high; when technology is rapidly obsoleting equipment and processes, the level of capital expenditures is high and instrument demands are high too. Capital expenditure plans are well documented. The predictions are for continued high levels of spending—hence Recorder-Controller people and Laboratory Equipment companies should expect good volume.

The estimated billions scheduled for industry's *research and development investment,* and which is a rapidly rising total, will continue to stimulate, as it has done in the past, the use of scientific and industrial instruments. Laboratory Apparatus and Optical Section people should benefit in this field.

Industrial Instrument Section people benefit from both sources and particularly as *military programs* such as missiles, rockets, radar, etc. increase the de-

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Condensed from address by H. F. DEVER, President of Brown Instruments Div., Minneapolis-Honeywell, and President of SAMA, 1956-57. Presented April 29, 1957, The Greenbrier, White Sulphur Springs, W. Va.

Incoming SAMA President R. E. Welch (left) Vice President and Treasurer of W. M. Welch Mfg. Co., receives gavel from retiring President H. F. Dever (right), President of Brown Instruments Div., Minneapolis-Honeywell Regulator Co.

mands for test instrumentation, not only in the laboratory but in the manufacturing processes.

And let us not overlook the *technological explorations* by the numbers of SAMA themselves which are continually extending the use of our products. Our people invest nearly three times more per sales dollar in research and development than the national average—or nearly five cents out of every dollar versus the national average of nearly two cents out of every dollar. Solving more problems in science, industry and engineering will produce greater take for our industry.

This emphasis on new products and new applications for existing products opens new frontiers for our growth. Typical of these is the industrial application of automatic data handling, the harnessing of atomic energy and related atomic pursuits in the laboratory, and the extension of our products into the missile and rocket field, already estimated a $1.2 billion industry although still in the research and experimental stages. There are, of course, many others.

Population Change

Yet, one of the single most important factors affecting the growth of our industry is people—a substantial increase in the number of people in general and, conversely, a critical shortage of specific people—engineers, scientists and so on. Statistically it breaks down like this:

> " . . . currently, some 67 million workers are providing for the needs of 170 million people. By 1975 an estimated 85 million workers will face the task of providing for the needs of some 213 million."

This gives you some idea of the productivity problem all industry is coming up against. To those of us in SAMA it means we will see a greater reliance upon our "tools" which, with the mechanical genius of industry generally, will help increase output per man-hour and in this way minimize some of this extra strain put on our working force.

There is every evidence that strenuous competition will continue to be the order of the day. Our products must keep abreast, if not ahead, of our customer's needs and our competitors' performance. We must continue to provide the "tools" with which our customers, in turn, can lower their costs, improve their product and make new and better things for the public. We must develop an awareness of instrumentation and automation abroad. Many countries now have the engineering brains to develop and exploit the advantages of automation. This can put them on the road toward modern U.S.-style mass production in considerably less time than it would normally take them. Foreign markets may be attractive areas for more of us to sell in. Foreign manufacturers may be an increasing competitive factor.

Public Relations

By almost any standards of comparison, SAMA is not really a large organization, yet we can take a degree of pride in the fact that for almost 40 years SAMA has been a spokesman for our industry. But maybe we don't do enough—particularly of a promotional nature.

Our Association as a whole needs a Public Relations and Public Information program. Last summer Jim Irving, with the valued assistance of the Association's Public Information Committee, planned a modest and somewhat experimental program to be undertaken in the coming fiscal year. This program was geared to an expenditure of about $12,000 and selected as its objectives those things which seemed to be of benefit to the Association as a whole, as contrasted with objectives which were of particular benefit to specific Sections. The program is geared to

Emery NEWS

WEIGHING SYSTEM

BIN, TANK AND HOPPER EDITION **No. 5**

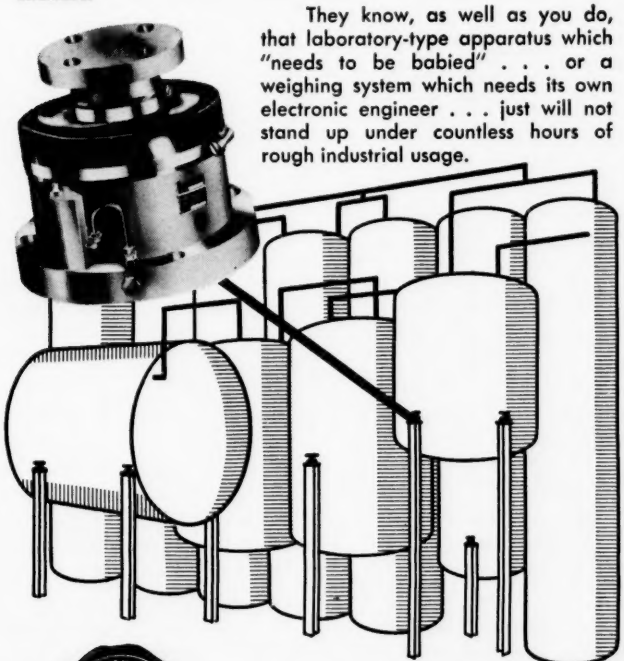
Covering design, development and application data on Emery Weighing Systems for industrial applications

TOP EXECUTIVES FIND EMERY WEIGHING SYSTEMS SUITABLE FOR TOUGHEST WEIGHING APPLICATIONS IN PROCESSING FIELD

Vision And Experience Team Up To Decide On Maintenance-Free Hydraulic Equipment

Men with progressive vision and broad experience in the processing industries are becoming increasingly aware of the need for positive action, extreme accuracy and maintenance-free long service life in the control equipment they buy for their plants. Why? Because in these days of tough "break-even" points and narrow profit margins, they can't afford to take chances.

They know, as well as you do, that laboratory-type apparatus which "needs to be babied" . . . or a weighing system which needs its own electronic engineer . . . just will not stand up under countless hours of rough industrial usage.



The Emery Load Cell is a "husky" piece of industrial equipment which combines years of satisfactory performance with amazing accuracy. A unique design called the "rolling ball" head accommodates reasonable off-center and cross loads. Even though Emery Load Cells utilize hydraulic pressure as a sensitive medium to measure loading they can be teamed with practically any brand or type of instrumentation manufactured today.

There are many good reasons why top executives are specifying Emery Load Cells for their bin, tank and hopper weighing applications. Our new Bulletin 561 describes them in detail. Send for this literature today.

A practical handbook on bin, tank and hopper weighing and the instrumentation involved. Write for it now!

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EDITORIAL—CONTINUED

supplement (but not supplant) Section programs. Section programs will continue to be operated and financed by Sections who undertake them.

Some of the projects which are in this program are already underway, thanks to funds made available by the Recorder-Controller, Laboratory Apparatus and Optical Sections. For instance, the SAMA program is trying now to add its help to efforts to alleviate the severe *shortage of scientists and engineers*. Let me take a moment to illustrate, as an example of good public relations, how your Association may be helpful in this problem.

You and I know that there is no quick and easy way to overcome this shortage. The various programs already advanced—the work-study programs, regional science fairs, making better use of the technical manpower available, the sponsorship of college fellowships in science and engineering—all of these are, of course, helpful—but they're only a good beginning. It's apparent that the solution will only come through broad and consistant effort covering several years. Even so, I do not think these programs get to the real root of the problem.

The critical shortage of scientists and engineers cannot be relieved until our teen-agers take more than their present lukewarm interest in science. High-school guidance counselors can have great influence in such decisions. A recent nationwide SAMA study revealed the startling fact that only nine per cent of the high school guidance counselors have a science background themselves!

Since more than fifty per cent of the youngsters make tentative career decisions before leaving high school—and a substantial number of the ablest, most successful high school students do not go to college—it is apparent that counseling, either as part of classroom teaching or special counseling services within a school, will have an important bearing upon the number of youths who first must be guided to attend college and then helped to decide on careers in science or engineering.

Currently the ratio of counselors ranges from a low of 1 counselor for every 1000 high school students to a high of 3 for every 1000. SAMA can fulfill one of its responsibilities as an industry leader and stimulate a program to relieve these beleagured educators trying to counsel high school students on science careers.

We propose that the talents of the more than 250,000 members of the nation's 275 professional societies be harnessed, on a community level, to assist the country's high school counselors in science advisory programs. A nationwide task force such as this, working at the discretion and direction of local educators on a neighborhood basis in every hamlet, town and city of this country, conceivably could do much to recapture the waning interest of our youth in science.

The only practical way to make a "major breakthrough" on this problem is to go to the grass roots where the problem is born. This plan, in which SAMA's role will be largely the catalyst, has already received favorable consideration from the Engineering Manpower Commission and the Scientific Manpower Commission.

This is just one example of an Association Public Information project, but shows how we can help solve some of our problems (and those of the nation, too, in some instances) and become better and more favorably known in the process.

It has been a wonderfully beneficial experience for me to have served this Association as its president these last two years. I again thank you for the honor and opportunity of being your president. I shall, in the future, try to repay your kindness by continued service to the Association wherever and whenever the need arises.

H. F. Dever

Dear D. R.*:

Your editors know that this issue is going to compete with swimming pools and mint juleps for your time—but this hasn't stopped us from loading it with powerful editorial material like these:

1. The article "Pneumatically Loaded Regulators" (second in Chet Beard's series on regulators) shows the great versatility and flexibility of the regulator that is loaded pneumatically via pilots. This article is basic, clear and thorough; it's worth at least a half hour of even swimming time.

2. The second article "Boiler Test" may well be of historic importance because it shows how a 950,000 pound/hour boiler is analyzed for instantaneous efficiency in New York while operating merrily in its boiler house in Western Pennsylvania. There is a clue to the future here.

3. The "Electronic Circuitry" feature shows a very stable time-delay, a cascode cathode follower, and an arc lamp control circuit, all interesting and useful.

4. The fourth article—Digital Differential Analyzers—is the first clear introduction to the DDA that we know about. You should know how the DDA operates—and this article will show you. Don't skip this article for any reason whatsoever, not even mint juleps.

5. The article "Numerically Controlled Positioning Table" tells you how to achieve (that is, how Resnick and Hayes achieved) 5-place positioning accuracy with four synchros. This is a useful technique.

6. The "Instrument Industry—An Economic Report" is a thorough analysis based on the most authentic figures available—the 1954 Census of Manufactures.

7. The article "Combined Analog-Digital Computing Systems" not only tackles an important question of the day—but resolves a hot argument that raged for a while in the S/C Newsletter and our Letters to the Editor.

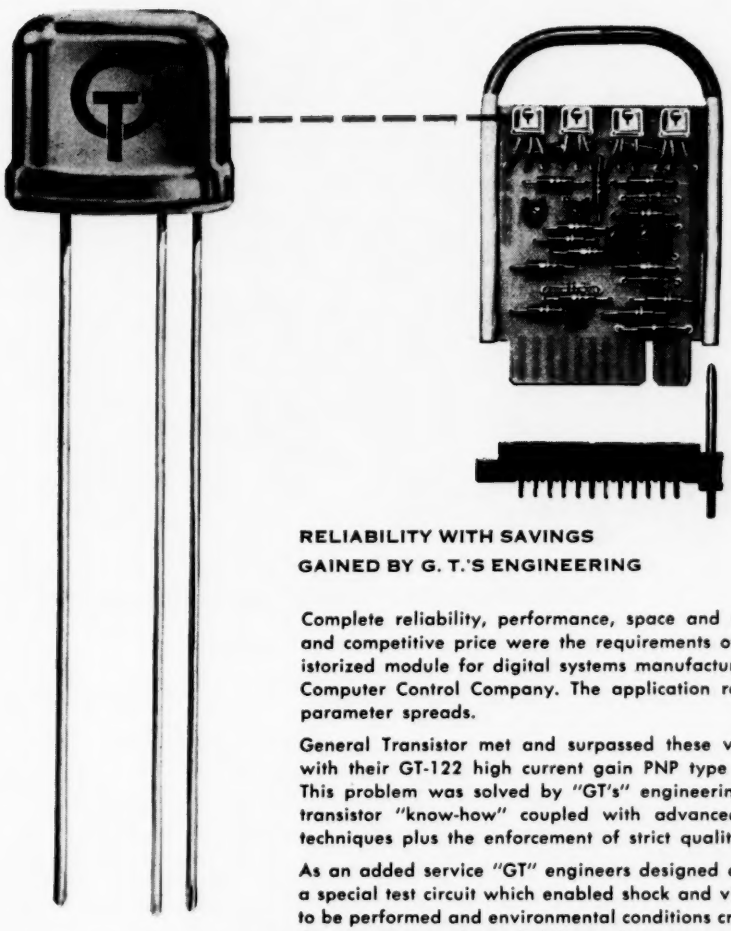
This is what we mean by a powerful issue. Hope it finds you (reading) well and happy this fine June.

Cordially,
Milt and the Editors

* Dear Reader

GENERAL TRANSISTOR

MEETS NARROW PARAMETER SPECS FOR COMPUTER CONTROL COMPANY'S ONE SHOT MULTIVIBRATOR



RELIABILITY WITH SAVINGS GAINED BY G. T.'S ENGINEERING

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General Transistor met and surpassed these very tight specs with their GT-122 high current gain PNP type transistor. This problem was solved by "GT's" engineering skill and transistor "know-how" coupled with advanced production techniques plus the enforcement of strict quality controls.

As an added service "GT" engineers designed and constructed a special test circuit which enabled shock and vibration tests to be performed and environmental conditions created to assure the customer complete reliability under extreme conditions.

This is just one more example of why **General Transistor is the fastest growing name in transistors.**

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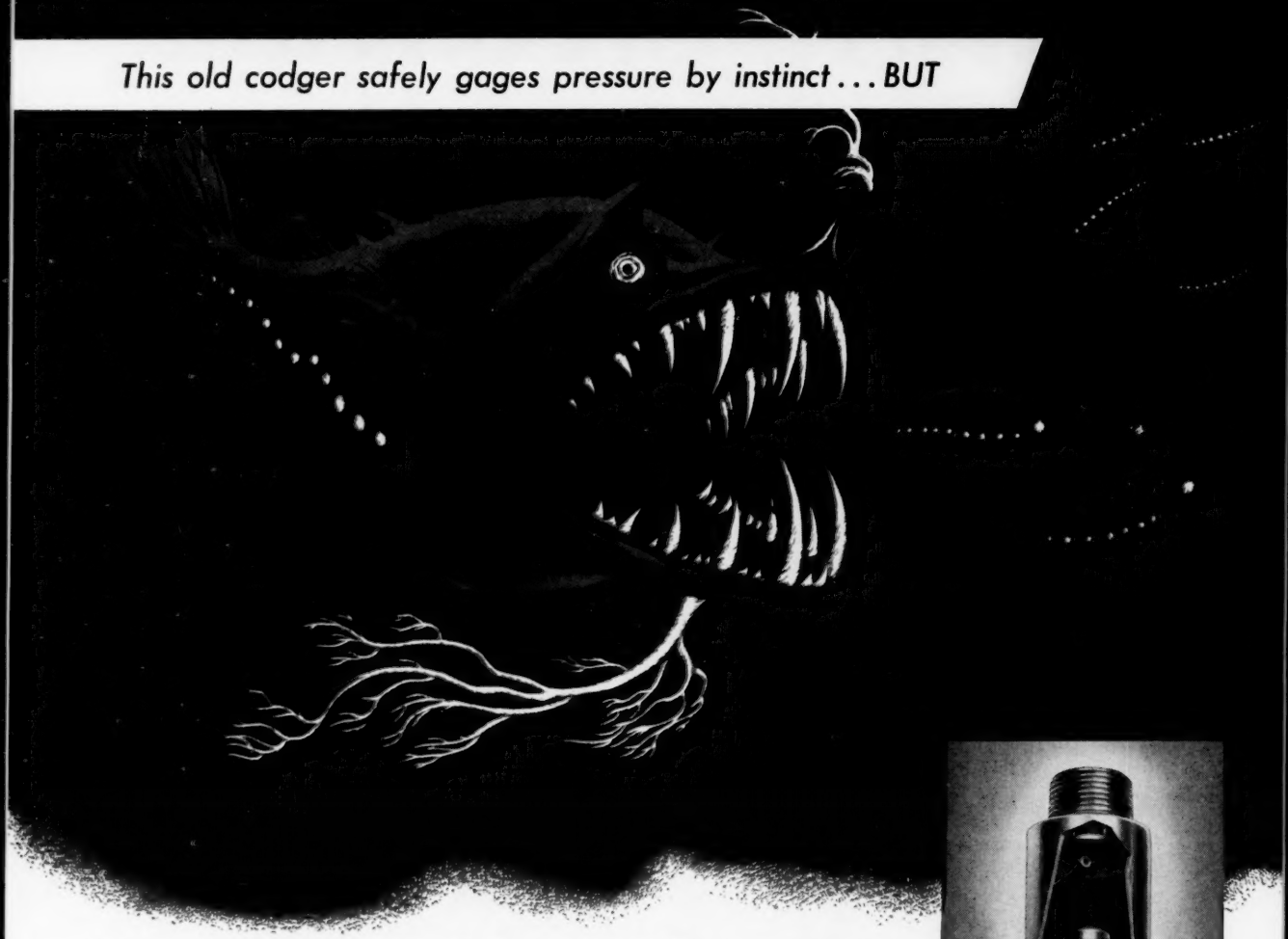
For more information circle **65** on inquiry card.

This old codger safely gages pressure by instinct . . . BUT

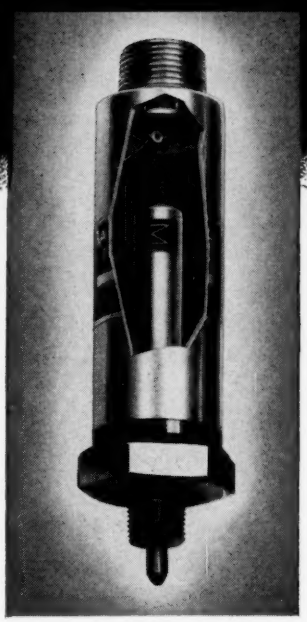


You can rely on SR-4® Pressure Cells to measure and control all industrial pressures safely to within ±¼% accuracy

The life of this toothy specimen depends on his staying at extreme ocean depths under many tons of pressure. If he ventures up too high—blooey! Suddenly diminished pressure causes him to literally explode.

B-L-H Fluid Pressure Cells are *the one way* to measure absolute or differential pressures with consistent accuracy to within ±¼%. They convert pressure changes directly into electrical changes —no moving parts to wear out, no long pressure lines with possible leakage and fire hazards. The signal can be fed to Baldwin indicators, recorders, controllers or data processing instruments—for our fishy friend, it could even activate a servomotor that would angle his fins downward and take him out of danger.

Whatever your pressure measurement problem, a B-L-H representative will be happy to help you, from selecting the proper transducer to engineering a complete pressure measuring system. Remember, a system is only as accurate as the transducer. Write today for your free copy of Bulletin 4306 on rugged, compact, reliable SR-4 Fluid Pressure Cells.



SR-4 Fluid Pressure Cells, using SR-4 Bonded Wire Strain Gages, are rugged, dependable and convenient. Typical cells show no loss of accuracy after 1,000,000 cycles of pressure at 100% of capacity. A wide range of SR-4 Pressure Cells is available for any industrial application.

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SR-4® strain gages • Transducers • Testing machines

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PHOTO COURTESY: NORTH AMERICAN AVIATION INC.

Three Genisco Accelerometers help the Super Sabre close in

If enemy air infiltration happens, you can be sure that modern knights of the sky powering the swift *Super Sabre* at speeds faster than sound will spearhead America's defense.

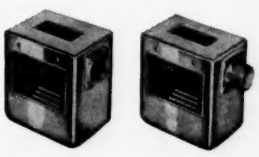
Typical of today's supersonic aeronautics, the USAF's *Super Sabre* reflects the finest contemporary engineering skill and scientific creative imagination. But this swept-wing assassin is more than just another jet-powered plane. It is a proven, integrated electro-mechanical system, combining a multitude of precision sub-systems, assemblies, and individual parts.

The automatic flight control system, for example, consists of numerous components, each one vital to the performance of the system. Naturally, component reliability is imperative if the plane is to carry out its mission. The flight control system of the F100D incorporates three Genisco Model DDL Accelerometers.

The Model DDL is only one of many Genisco Accelerometers now in use on America's air guardians, including our most important operational guided missiles. Like other models, the DDL was designed for a particular application—to function perfectly in the severe vibrational and shock environment of supersonic flight.

Genisco's ability to design for the most stringent applications and to produce precision instruments in large quantities has made the company an important link in our nation's defense chain.

Descriptive technical data on the Model DDL and other Genisco accelerometers will be sent upon request.



Genisco
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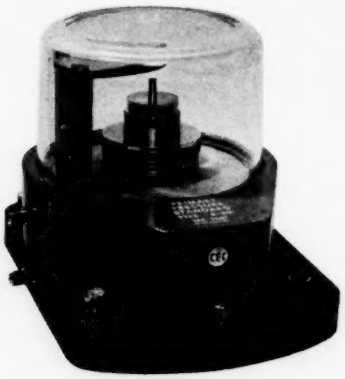
A new primary standard with .015% accuracy



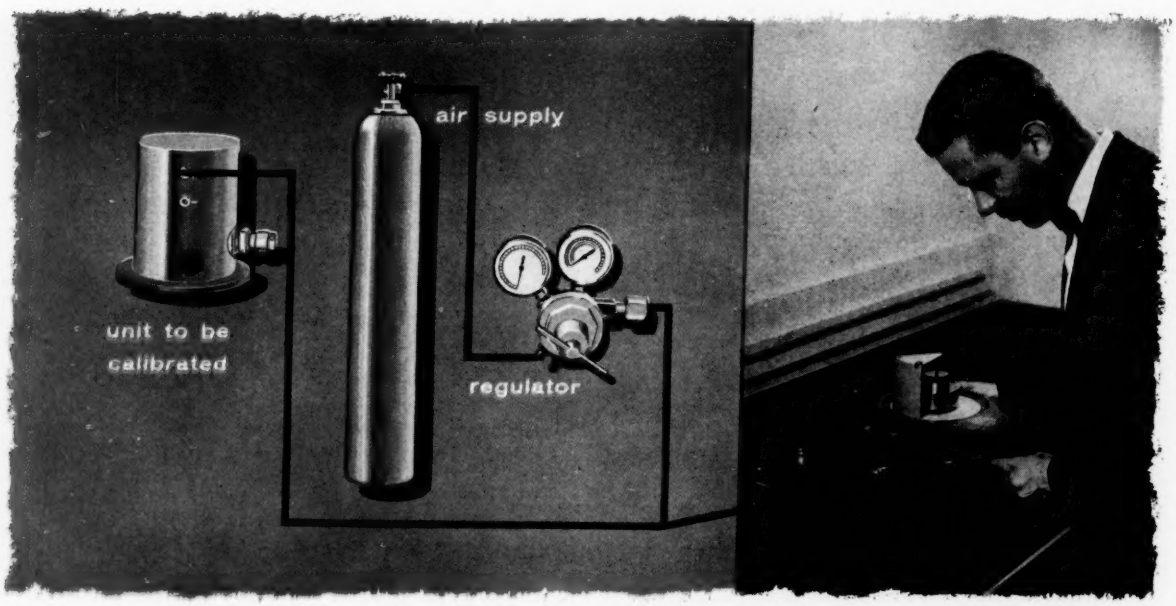
Amazing accuracy of .015% in all pressure ranges is now assured with Consolidated's new Primary Pressure Standard. Operating as a true primary standard (air dead-weight tester), the 6-201 offers the advantages of a frictionless pressure medium, extreme accuracy even at pressures of less than one psi, and portability regardless of the pressure range.

Pressure calibration is achieved by balancing a controllable air pressure against the force generated by a weighted piston. Simple combinations of different piston-cylinders and weights provide four ranges within the limits of 0.3 to 50 psi.

EASY TO OPERATE IN BOTH GAGE OR ABSOLUTE USE Used as a gage type instrument, all you need is a dry air supply, a regulator, and the device being calibrated. When the 6-201 is used as an absolute device, its glass cover can be evacuated through a pressure fitting.

Maintenance-free and easy to use, CEC's Primary Pressure Standard is unexcelled for calibrating pressure-measuring devices. Contact your nearby CEC field office, or write for Bulletin CEC 1581-X4.

CEC's Primary Pressure Standard



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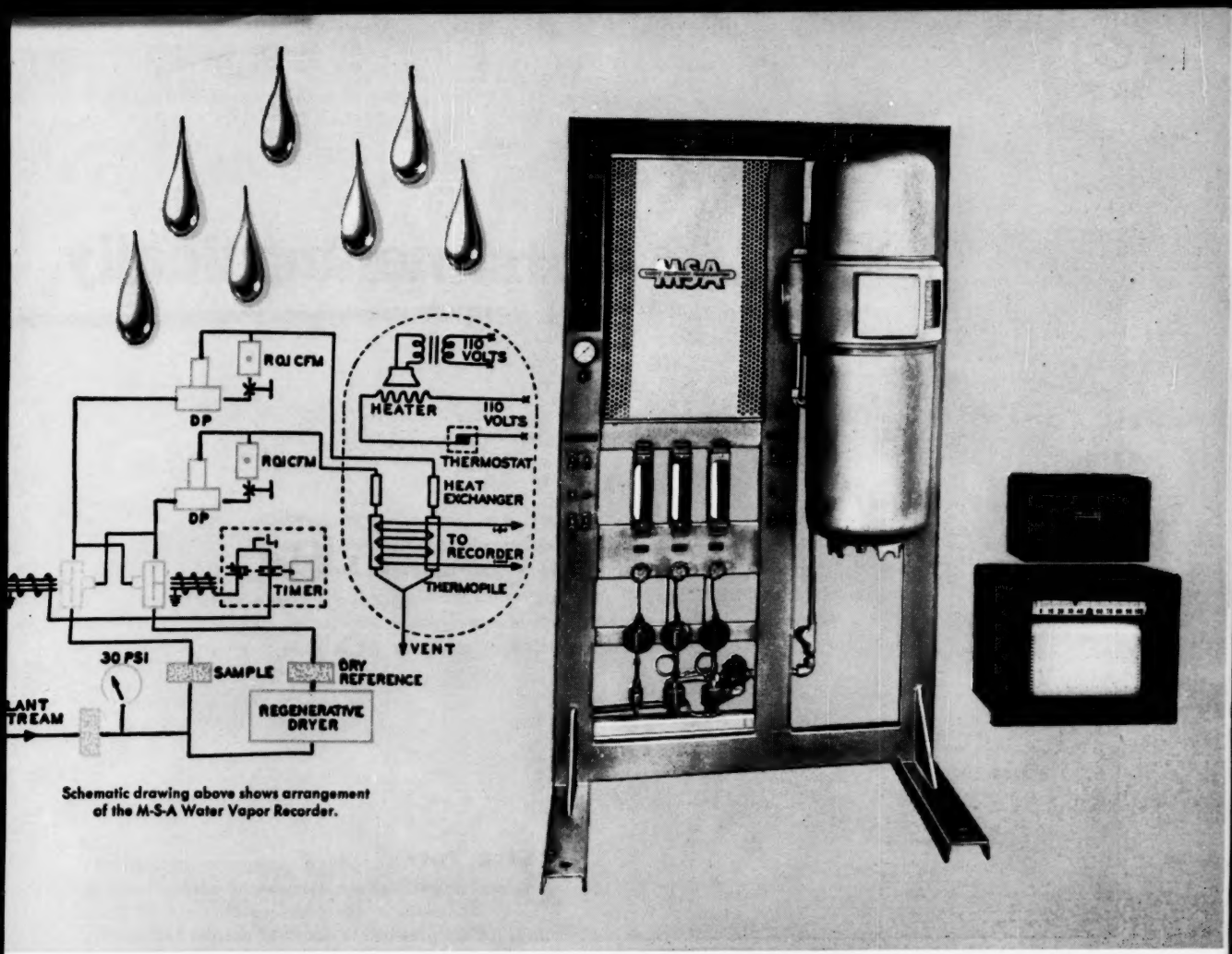

Schematic drawing above shows arrangement of the M-S-A Water Vapor Recorder.

The M-S-A Water Vapor Recorder operates on a new principle, based on measurement of the heat energy exchanged when a gas is adsorbed on or desorbed from the surface of a solid adsorbent.

M-S-A® Continuous Water Vapor Recorder detects trace moisture in air or gas streams

The M-S-A Water Vapor Recorder is an extremely accurate instrument which can solve a great number of moisture problems occurring in process industries as well as gas pipelines.

This unit continuously records low concentrations of water vapor in air or gas streams, and analyzes in the range of 0 to 10 up to 0 to 5000 ppm. It's particularly effective for monitoring natural gas in pipelines, thus avoiding undesirable moisture conditions. Of further value is the instrument's ability to maintain the efficiency of drying towers by monitoring effluent gases. This permits regeneration to begin just before or immediately upon the first water break-through.

This newly developed instrument is useful, too, for preventing moisture damage to process catalysts by monitoring feed streams, and for the detection of small amounts of water, so critical in controlling corrosion.

Typical applications for this dependable instrument include measurement of water or water vapor in streams containing: LPG, Ethylene, Natural Gas, Freon, Naphtha and other feed stocks. Write for our free bulletin for further information.

MSA

INSTRUMENT DIVISION

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Pneumatically

C. S. BEARD
General Controls Co.

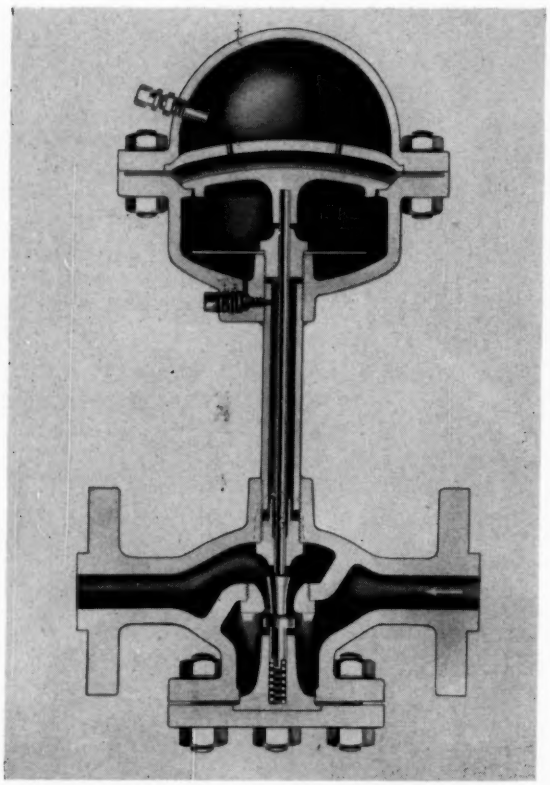
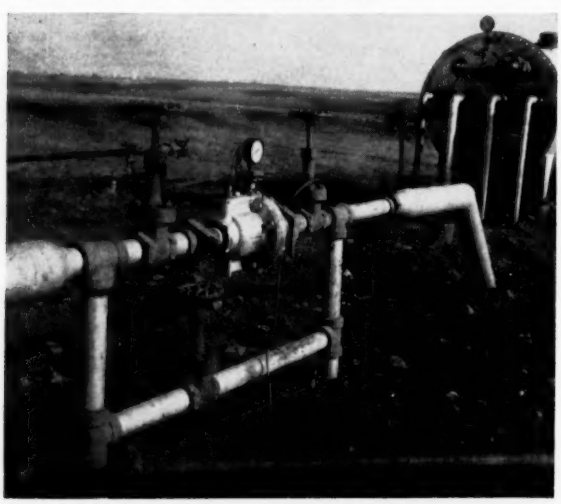


Fig. 2-1. Constant pressure locked in dome balances line pressure in this constant-pressure-loaded regulator.

Fig. 2-2. Large capacity of external tank for constant-pressure loading decreases variation from set pressure. External tank is buried to decrease loading-pressure changes due to ambient temperature.



BASIC ADVANTAGE of pneumatic loading over mechanical loading (weight or spring loading, as discussed in the previous chapter) is flexibility. An air pressure is easier to change and modify than is a weight or spring. The basic methods for pneumatic loading of pressure regulators include (1) constant-pressure loading, (2) variable-pressure loading, (3) differential spring-pneumatic loading, and (4) differential weight-pneumatic loading.

Constant-Pressure Loading

In *constant-pressure loading* of a regulator the pressure may be locked in a dome, as shown in Fig. 2-1. The locked-in pressure will increase or decrease as the diaphragm moves to open or close the inner valve, thereby resulting in variation from set point. The amount of variation from the set point depends on the capacity of the loading chamber and the amount of inner valve travel, the latter, in turn, depending on valve size. Hence the dome loader (Fig. 2-1) is not used for valves with a valve port larger than 1½".

The maximum set pressure is limited only by the construction of the valve and dome. Regulators of this type are available for control of pressures as high as 3,000 psig.

The larger the capacity of the dome in Fig. 2-1, the lower will be the variation from set point caused by valve action. Use of a larger external capacity chamber, as shown in Fig. 2-2, decreases the deviation from the set point. The style of valve shown in Fig. 2-2 is being used extensively for relief or back-pressure control on gas pipelines.

Loaded Regulators

Regulators—No. 2

Pneumatic loading of a regulator provides increased flexibility and versatility. Still greater flexibility is realized by use of pilots and combinations of pneumatic and spring or weight techniques for loading the regulator. Here is a survey of constant-pressure loading, variable-pressure loading, differential spring-pneumatic loading, and differential weight-pneumatic loading.

Use of Pilots

Constant-pressure loading can be broadened to include large valves by using a small pilot regulator to hold the loading pressure constant (Fig. 2-3) instead of attempting to lock the pressure in a chamber. In this method the deviation from the set point is limited only by the ability of the pilot to inject the loading medium into the diaphragm chamber (or relieve it from the chamber) at the rate required by movement of the diaphragm.

Note that the pilot has the same elements as the spring-loaded pressure regulator described previously. However, the basic advantage of the pilot lies in the fact that it has short stem travel. Thus the inevitable change from set point due to change in *effective area* of the diaphragm, or change in spring rate, is minimized.

Pilots differ in the way they inject and relieve pressure from the main regulator. Three methods are in use: (1) A pilot valve as in Fig. 2-3, which holds the pressure constant by discharging into the system when the pressure falls below the set point of the pilot (or relieves pressure when required). (2) A pilot regulator which discharges into the system to hold a pressure which is depleted by a constant bleed to the atmosphere. (3) A pilot regulator that relieves a pressure created by a constant supply through a restrictive orifice. Each can be designed to bleed into either the low-pressure side of the main line or to atmosphere.

In systems (2) and (3) a small reducing regulator is used with a set bleed. Fig. 2-4 shows a system representative of (2) and using such a bleed. The bleed

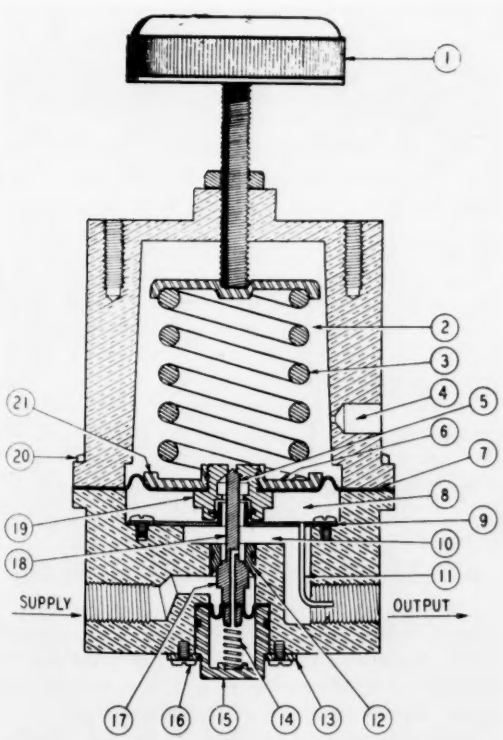


Fig. 2-3. Pilot regulator opens intake port (17) or relief port (5) to hold a constant loading pressure at output, which is used to load pressure regulator. Main diaphragm (7) is balanced between spring (3) and output pressure (8). Pressure-balancing chamber (15) provides added stability.

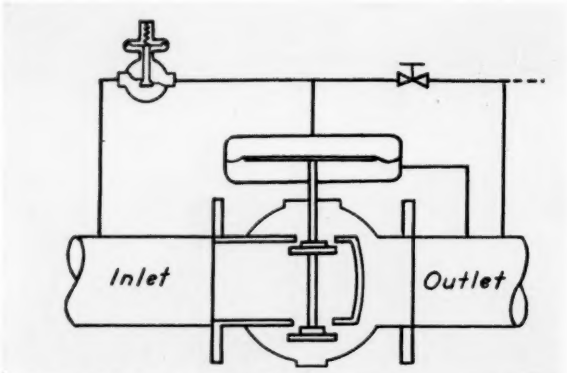


Fig. 2-4. Pilot regulator supplies line pressure to regulator as required to hold loading pressure at a constant value. For reduction of pressure to regulator, bleed is used to either atmosphere or main line.

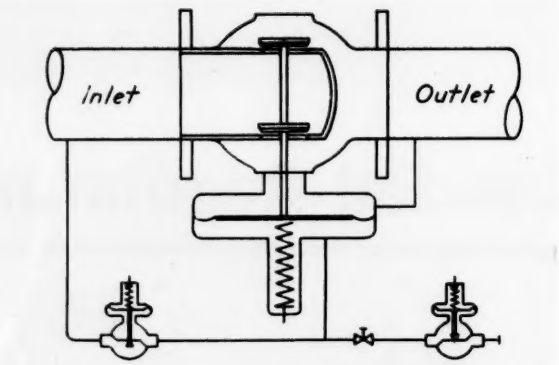


Fig. 2-6. Equalizing spring reduces pulsation in a balanced valve, which can use a more sensitive diaphragm.

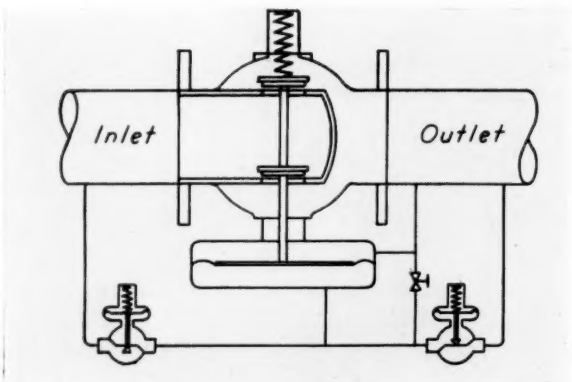


Fig. 2-5. Constant-pressure-loaded regulator with addition of equalizing spring and safety pilot that bleeds to downstream.

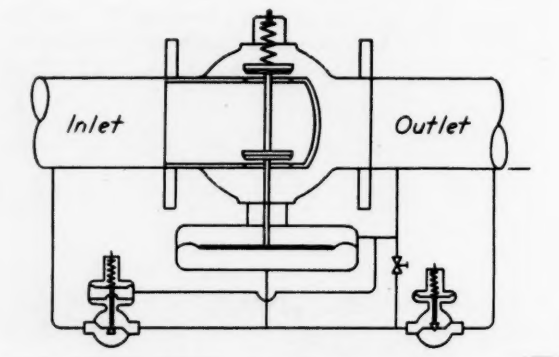


Fig. 2-7. In variable-pressure loading, pilot is responsive to changes in outlet pressure.

and supply must be sufficient to handle the change in volume caused by change in diaphragm position, but must not be in excess of the volume that can be delivered by the pilot regulator. In these systems the weight of the parts and the unbalanced forces involved must be considered, as follows:

The diaphragm is balanced between the controlled pressure on one side and loading pressure on the other (see Fig. 2-4). Loading pressure, weight of the parts, and differential unbalance tend to open the valve; controlled pressure tends to close the valve. Thus:

$$P_3A_D + W + (P_1—P_2)\,(A_{diff}) = P_2A_D$$
$$P_3 = P_2 — (\Delta P)\,(A_{diff}/A_D) — W/A_D$$

where P_3 is loading pressure in psig; A_D is *effective area* of diaphragm in sq in; $(P_1—P_2)$ is ΔP or differential across valve seats in psi; A_{diff} is difference in seat areas in sq in; W is weight of parts in lb.

Bleed into the main line is desirable when the line fluid is valuable or is undesirable as a bleed to atmosphere, as is the case with most gases. When bleeding to the main line, the loading pressure must be greater than the controlled pressure to get the bleed gas back into the line. The weight of the parts assist in this respect when the diaphragm case is under the body.

Here:

$$P_3A_D + P_2A_D = W + (P_1—P_2)\,A_{diff}$$
$$P_3 = P_2 + (\Delta P)\,(A_{diff}/A_D) + W/A_D$$

Although it has been assumed that the loading medium is the fluid flowing in the line, the loading medium can be instrument air. This permits the loading pilot regulator to be mounted at a remote point. However, if this is done, consideration must be given to the time lag introduced by tubing between the pilot and the regulator. Unless otherwise noted, all "regulators" are assumed to operate only from the line medium.

A nomenclature* has been proposed for the many variations of pilot systems now in use, as well as for specifying the operating characteristics. Using the simple form of pilot loading shown in Fig. 2-4, the designation by the proposed method of classification would be: *pilot regulator, constant pressure, balance loading, reverse acting, no equalizing spring.* The term "balance loading" refers to the fact that the diaphragm is balanced by two pressures. The term "reverse acting" refers to the fact that loading pressure opens the valve.

Equalizing Spring

Fig. 2-5 shows a system with the addition of an *equalizing spring* and a *safety pilot* regulator for un-

*Proposed by Allen D. McLean

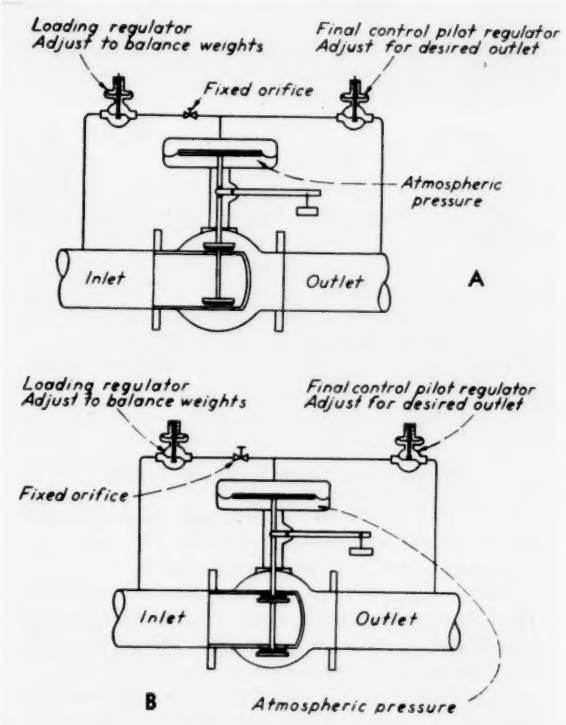


Fig. 2-8. Constant force of a weight on beam is employed to actuate line valve, which is loaded on one side by two pilot regulators. One side of the diaphragm is open to atmosphere. Inlet pilot is adjusted to balance weight. Control pilot adjusts outlet pressure. In A, failure of diaphragm will cause valve to open; in B to close.

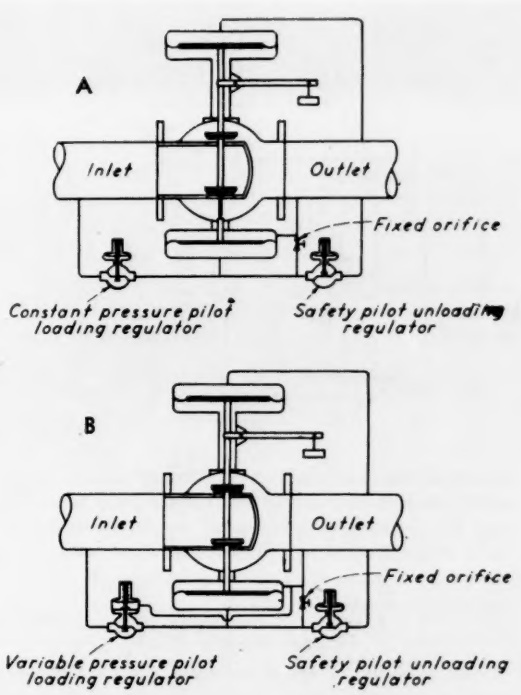


Fig. 2-9. Conventional weight loading added to pilot system. Upon failure of the lower balance diaphragm or pilot, the balanced diaphragm loses contact with stem and weight-loaded-regulator operation begins. System A is constant-pressure loaded; B is variable-pressure loaded.

loading or bypassing the loading pressure into the downstream side of the main line. Here the bleed can be piped back into the line downstream of the regulator because the equalizing spring opposes the loading pressure so that the loading pressure is greater than the controlled pressure. This regulator would close upon rupture of the diaphragm or a failure in the pilot system.

The equalizing spring in Fig. 2-4 is used to increase stability and reduce pulsation because the balanced regulator can use a more sensitive diaphragm than the single-seat regulator. The pulsation which could result from use of a sensitive diaphragm is counteracted by the equalizing spring.

The spring also will open or close the valve under emergency conditions, depending on how the spring is installed. The system shown in Fig. 2-5 can be designated as *pilot regulator, constant pressure, balance loading, reverse action, spring opposes loading pressure.* The system shown in Fig. 2-6 can be designated as *pilot regulator, constant pressure, balance loading, reverse acting, spring acts with loading.*

Variable-Pressure Loading

All the regulators described thus far have been constant-pressure loaded; the pilot maintains a constant loading pressure as established by adjustment of a spring in the pilot. Any change in controlled pressure of the main line is *not* reflected by a change in loading pressure in a constant-pressure-loaded regulator.

In variable-pressure-loaded regulators, however, the pilot *is* made responsive to the controlled downstream pressure. This is done by using a variation of the balanced-diaphragm valve as a pilot, as shown in Fig. 2-7. The pilot may be direct or reverse acting. The system shown in Fig. 2-7 is now a *pilot regulator, variable pressure, balance loading, reverse acting, spring opposes loading system.*

Variable-pressure loading can be applied to higher unbalanced forces such as occur in single-seated valves.

Differential Weight-Pneumatic Loading

The constant force of a weight on a beam is used to operate the line valve (pressure regulator) in Fig. 2-8. The line valve is loaded only on one side (instead of balance loaded) because one side of the diaphragm is open to atmosphere. In operation, the inlet pilot is adjusted to balance the force of the weight. The restricting orifice allows the control pilot at right to load or unload the diaphragm (when the spring is manually adjusted) until the downstream pressure equals the desired pressure.

Fig. 2-9 shows systems in which conventional weight loading has been added to pilot systems. Upon failure

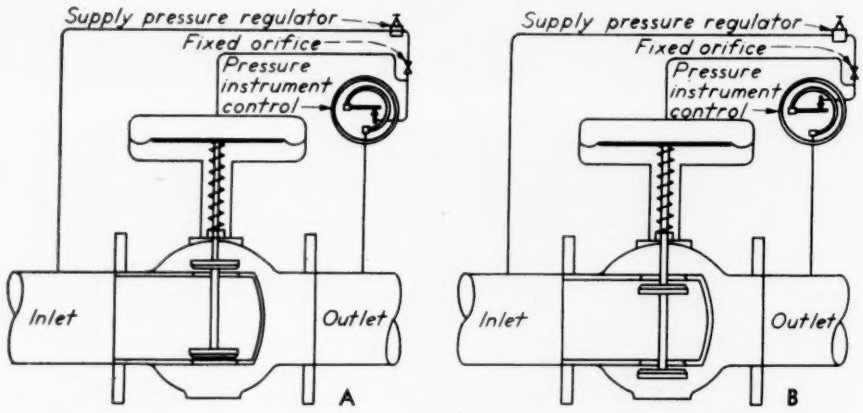


Fig. 2-10. Use of flapper-nozzle pilots of "instrument" type.

of either the lower balance diaphragm or the control pilot, the balanced diaphragm loses contact with stem and conventional weight-loaded regulation action begins. Note that this is a dual system. Note also that A shows a constant-pressure pilot system, B shows a variable-pressure pilot system.

Flapper-Nozzle Pilot

Fig. 2-10 shows use of pilots of the flapper-nozzle type, commonly found in full instrument-type controllers. As no separate air supply is shown, these devices can be classified as regulators. To follow the recommended nomenclature, A shows *flapper-nozzle-pilot regulator, variable-pressure loading, bleed to atmosphere, direct acting;* B shows *flapper-nozzle-pilot regulator, variable-pressure loading, bleed to atmosphere, reverse acting.*

Pilots of the type shown in Fig. 2-10 permit refinements for various control actions—adjustable proportional band, etc.

Regulators with Integral Pilots

Regulators have been designed with all the features described—variable-pressure loading, etc.—in one completely piped and integral unit. Fig. 2-11 shows a regulator with variable-pressure loading. Note the simple piping; all that is required is a line from the upstream and downstream sides of the line to the pilot, and one tap to the regulator.

In one design (Fig. 2-12) the pilot is in the body of the line valve. In this unit the upstream pressure is applied to the top of the main diaphragm and will tend to close the valve. Increase in downstream pressure above the setting of the pilot spring will move the seat away from the upper ball of the pilot plug. This will bleed the pressure below the line valve diaphragm, and tend to close the line valve. Decrease in controlled pressure will close the (upper) bleed port and open the lower port, which allows loading pressure to open the valve. A neutral equilibrium position results

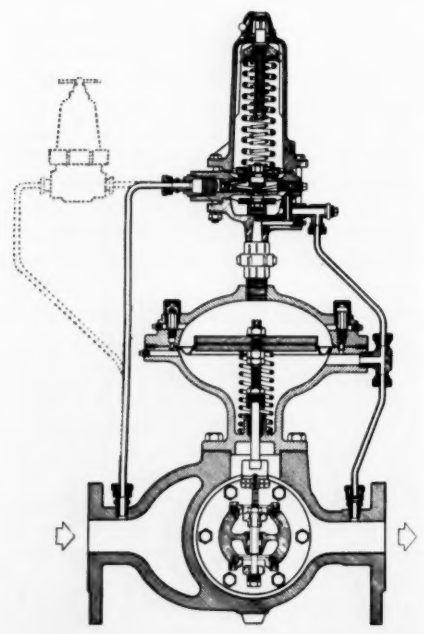


Fig. 2-11. Variable-pressure-loading regulator and pilot are incorporated in one integral unit.

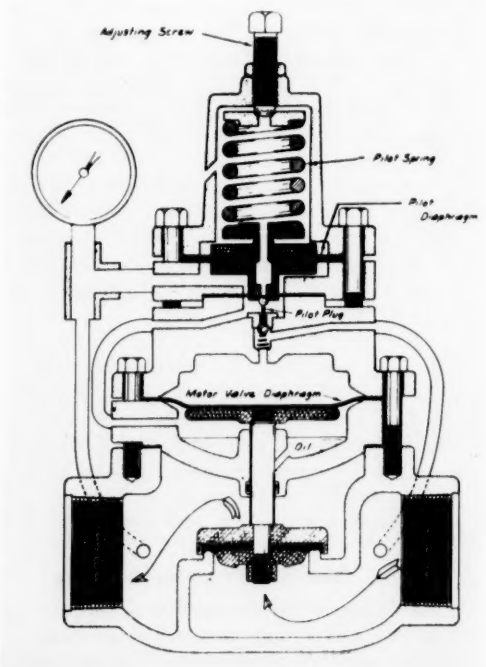


Fig. 2-12. Pilot mechanism is incorporated in line valve in this design.

whereby both portions of the pilot plug are seated, and no bleed or additional supply occurs.

Pilot-Operated Piston-Actuated Regulators

Further integration of the pilot into the body is illustrated in Fig. 2-13, which shows a piston-operated regulator. Other pilots may be used to make this same body a vacuum regulator, pump governor, control valve, or temperature regulator.

Constant bleed can be obtained in three ways: (1) by controlled clearances past the rings of the piston, (2) through a drilled hole in the piston, or (3) through a needle valve built into the body. The bleed port in the body can be covered by the body gasket so that the port (which is shown plugged in Fig. 2-13) may be open to atmosphere, or piped as desired. A spring supports the piston and inner valve so that the operating pressure will be higher than the controlled pressure, allowing the bleed to pass into the low-pressure side of the regulator.

Remote pressure from a manual loading regulator can be used to replace the hand-screw for setting the pilot regulator. The piston of the actuator shown in Fig. 2-14 is approximately the same diameter as the seat ring. The pilot valve is positioned by a diaphragm actuator of the same types as is used for a standard globe control valve. The piston of the actuator opens a port to allow high-side pressure into the chamber above the piston, making this a completely balanced single-seated valve. Additional movement of the stem of the actuator positions the piston and the inner valve as dictated by the output pressure of the controller being used.

Advantages of Balanced Operation

Balanced valve operation, as in Fig. 2-14, or by use of balanced-diaphragms, etc. has many advantages*:

1. Uniform pressure on diaphragm through full stroke of regulator or valve.

2. Minimum differential across diaphragm. Weight- and spring-loaded units have downstream pressure on one side of the diaphragm and atmospheric pressure on the other side.

3. Readily adaptable to various methods of snubbing or slowing down of diaphragm action.

4. Larger diaphragm case sizes may be used for greater sensitivity.

5. Regulator may be controlled remotely by pilots located up to several hundred feet away.

6. Thinner or more sensitive diaphragm material can be used because of the limitation in differential across the diaphragm.

7. Pilot can be made an integral part of the regulator.

8. Can be used in combination with weight or spring loading to obtain minimum outlet pressure on pilot failure.

9. Pilots are readily adaptable to extended static control lines.

10. Pilot changes may be made by telemetering techniques.

11. Various fail-open or fail-closed conditions can be obtained.

*Suggested by J. E. Gesner of Reliance Regulator Co.

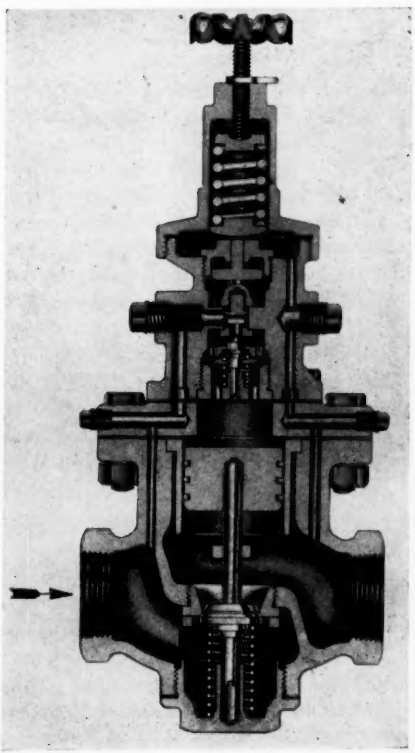


Fig. 2-13. Piston-operated valve is positioned by pilot designed as part of the valve.

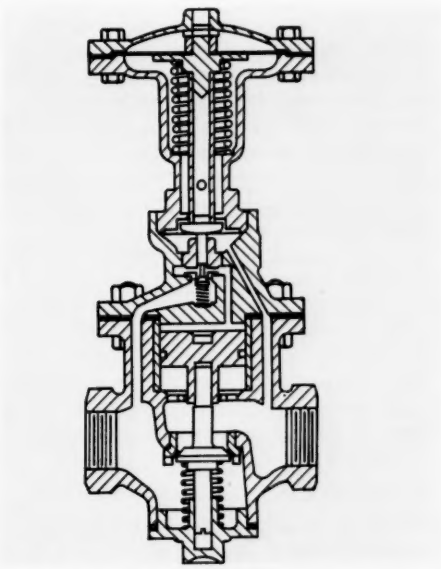


Fig. 2-14. Remotely varied pressure may be used to change set point of this pressure regulator with built-in pilot and piston actuator.

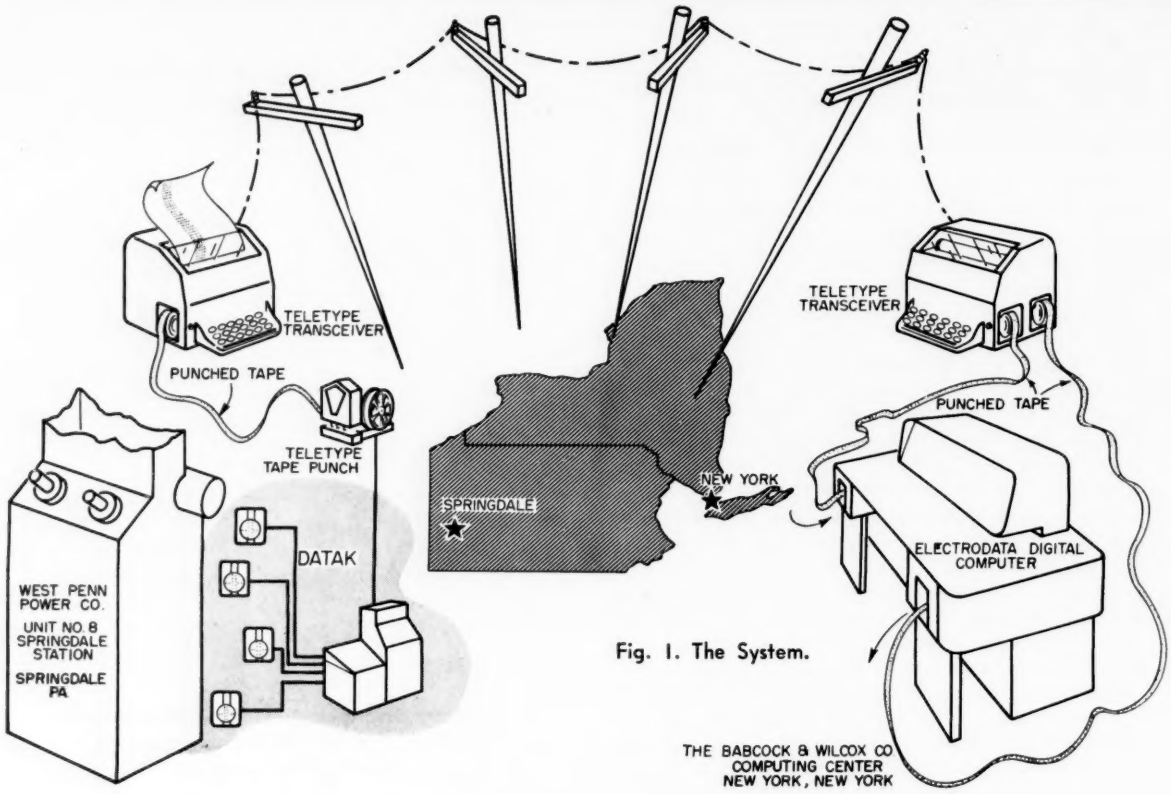


Fig. 1. The System.

Boiler Test Via A

THE BOILER used for test, a Babcock and Wilcox reheat type rated at 950,000 pounds of steam per hour, at 1550 psig, 1000°F superheat out and 1000°F reheat, went in service in June, 1954. The station is located on the Allegheny River about 20 miles northeast of Pittsburgh.

The program was motivated by a desire to reduce the manpower and time required for field test work on boilers. Equipment was visualized which could be readily installed in a power station and operated by a crew of two or three men. The data output would be in a form ready for transmission to remote computer. Teletype was visualized as a convenient link to the computer to reduce the elapsed time between testing and obtaining computed results. Such a system should reduce testing costs and make economically feasible more extensive test programs.

Fig. 1 shows the basic system. The data system—DATAK— was installed on a boiler near Pittsburgh, Pennsylvania, and teletype communications established with a computer in New York. Thus data taken in Springdale were transmitted to New York, fed into the computer, and the results transmitted back to Springdale. The results of any given test run could be back at the station in less than an hour from the start of the test.

Abstract of paper 57-SA-61, "A Discussion of an Application of Automatic Digital Data Collecting System to Boiler Testing," by J. H. Bail, C. E. Jones and H. T. Hoffman, presented at the 1957 Semi-Annual Meeting of The American Society of Mechanical Engineers, June 10, 1957, San Francisco, Calif. Companion paper 57-SA-58 "An Automatic Digital Data Collecting System for use in Central Stations," by W. T. Hage and H. T. Hoffman, was also presented.

DATAK

DATAK (Fig. 2) consists of several analog scanners and a control console. The analog scanners convert the various primary element signals into a standardized analog signal. Each scanner has 25 sequentially selectable inputs and one output. The central control console contains the logical circuits which (1) select the desired scanner and primary element and (2) convert the standardized analog signal to a code punched in paper tape. The DATAK equipment is shown pictorially in Fig. 2.

Portability and flexibility are emphasized in the design of DATAK. All components of the system are relatively small and easily moved about a station.

Hand-set potentiometers located on each scanner and connected in place of thermocouples allowed data which would not be directly measured to be punched into the paper tape. The fuel and refuse analysis, standard losses, etc. were entered in this manner.

The installation was complete and de-bugged by August 22, 1956, and removed on September 17, 1956. In the interim 322 test runs were made without equipment failure. DATAK was operated by a two-man crew although there usually were more people on the job in order that as many as possible might gain experience.

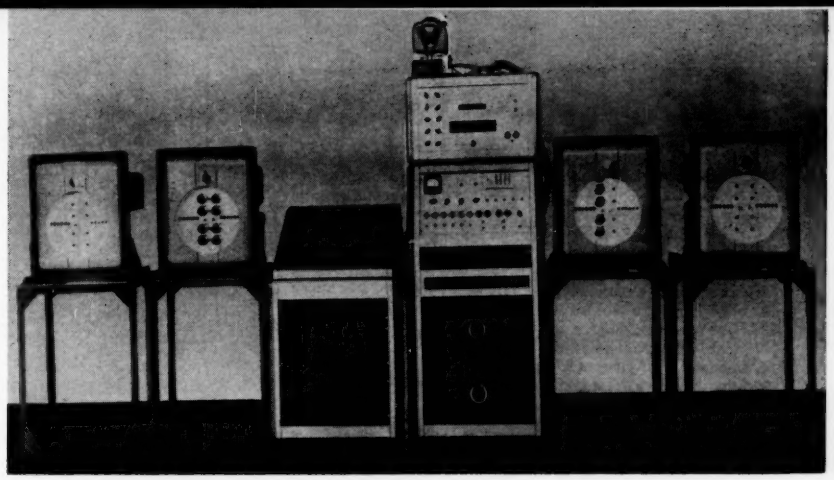


Fig. 2. DATAK.

J. H. BAIL
West Penn Power Co.

C. E. JONES
The Babcock & Wilcox Co.

H. T. HOFFMAN
Bailey Meter Company

In the summer of 1955 The Babcock & Wilcox Company and the Bailey Meter Company embarked upon a joint program to investigate some of the possibilities of automatic data taking, directed toward the area of testing large central station power generating units. The technique and results may well be of historic importance. Here is the installation and use of this equipment on West Penn Power Company's Springdale Unit No. 8.

DIGITAL DATA SYSTEM

Tests Performed

The boiler was instrumented to allow the calculation of boiler efficiency, the heat absorbed in each part of the convection pass, the gas temperature entering and leaving each section of the convection pass, and the over-all conductance of each major section of the convection pass.

Table I lists the data points, and Figs. 3 and 4 show their location on the boiler and the fluid cycle respectively. All temperature measurements were made with iron-constantan thermocouples. The pressure and draft measurements were made with commercially available transducers. Flows were measured using the existing station flow meters.

The proper location of the points of measurement for boiler testing must always be considered carefully. The most difficult choice is probably that of thermocouple and gas sampling locations for determining flue-gas temperatures and oxygen content. In this installation a geometric matrix of thermocouples and gas sampling probes was installed in the flue gas duct. In the calculations, an arithmetic average of the matrix readings was used as the value of temperature or percentage 0_2.

The installation of thermocouples in the gas stream in a manner similar to the one used during this program can have two purposes. One purpose is to determine local values of gas temperature, the other is to determine an average value of the gas temperature.

If the object of the measurement is to study contours and how they change with operating conditions, then a large matrix with a fine mesh is required. The matrix used at Springdale was not large enough to accomplish this purpose adequately. However, the ability to increase the size of this system is obvious. The determination of an average value for gas temperature would normally require a matrix with a much coarser mesh than the one that was used, but which would still result in substantially the same average value. Fig. 5 shows the configuration of the flue gas composition and temperature sampling matrices used at the air heater outlet. The average of the circled points will give an answer essentially the same as the average of each of the matrices. These fewer points may be selected by manually traversing the duct and selecting locations which give readings consistent with the average of the traverse.

This demonstrates that for this boiler and this test, it would be possible to use only a few points in the matrix and obtain essentially the same results.

Data Accuracy

The *static accuracy* is determined by error introduced at three places in the system—the primary ele-

Table I—DATAK Data Points

Temperatures

T1. Air heater air outlet	(12 I.C. Thermocouples)
T2. Air heater air inlet	(2 I.C. Thermocouples)
T3. Air heater gas outlet	(18 I.C. Thermocouples)
T4. Economizer gas outlet	(18 I.C. Thermocouples)
T5. Economizer gas inlet	(18 I.C. Thermocouples)

T6. Economizer water outlet
T7. Economizer water inlet
T8. High pressure heater water inlet
T9. High pressure heater water outlet
T10. High pressure heater drain
T11. Feedwater at flow nozzle
T12. Superheater attemperating water
T13. Reheat attemperating water
T14. Superheater attemperator steam inlet
T15. Superheater attemperator steam outlet
T16. Secondary superheater steam outlet
T17. Reheater steam outlet
T18. Reheater attemperator outlet steam
T19. Reheater attemperator inlet steam
T20. High pressure heater steam
T21. Gas Temperature between Secondary Superheater and Reheat Superheater. (3 C-A Thermocouples)

Pressure, Draft, Differential

P1. Drum
P2. Superheater outlet
P3. Reheater inlet
P4. Reheater outlet
P5. High pressure heater steam
P6. Feedwater
P7. Air heater air inlet
D8. Air heater air differential
P9. Air heater gas inlet
D10. Air heater gas differential
D11. Convection pass differential
D12. Economizer gas differential

Flow

F1. Feedwater
F2. Superheater attemperator
F3. Steam flow
F4. Air flow (in clean airduct before air heater.)

Gas Samples

1. % O_2 at air heater outlet (9 points)

ments and transducers, the scanners, and the analog-to-digital conversion process.

In the case of temperature, the primary elements were I.C. thermocouples which were calibrated prior to the start of the test program and were assumed to be stable over the period of the test. This means that the errors introduced by the thermocouples were considered constant for the test period. The pressure, flow, draft and differential transducers were calibrated prior to the test in such a manner as to minimize the error in the operating range. A check of these calibrations near the end of the test disclosed no change from the original calibration.

It is possible for the analog converters, that is, the scanners, to introduce errors from three sources—(1) the values of the circuit resistors, (2) the linearity of the analog conversion, and (3) the stability of the reference voltage. Since the linearity of conversion is a function only of the tracking of two slidewires on the same shaft, this is assumed constant for the period of the test. The circuit resistors and reference voltage stability were checked periodically throughout the test and no drift was found within our ability to field-check, which was 1F° for temperatures, and 0.1% of range for flow, pressure, and differential.

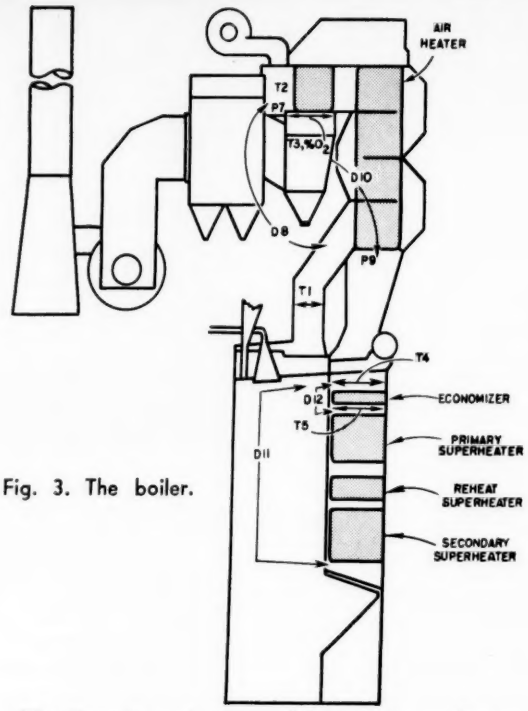


Fig. 3. The boiler.

The linearity and zero stability of the analog-to-digital converter is 1 digit in the least-significant position, making this contribution to over-all error very small.

Thus it is concluded that the system calibration as influenced by the above-mentioned factors remained stable throughout any one test, allowing direct comparison of answers without the application of correction factors to the data.

No estimate of the *absolute accuracy* of the results can be made. The time available for the Springdale tests precluded establishing an absolute calibration for the system. Therefore, the real value of the tests was to establish the reliability and repeatability of the DATAK equipment. It was not possible to obtain information useful in evaluating boiler design, operation, or instrumentation.

Random errors are introduced in the data from several sources which may be grouped as follows: (1) that inherent in the equipment, and (2) that induced by environment. In this installation, we were not able to detect any errors introduced by the environment, since whatever existed was masked by equipment errors.

In order to establish the repeatability of the calculated results, the repeatability of each measurement was established. By combining the results of tests on the analog scanners, analysis of the variation in hand set items and our maintenance experience, it was possible to establish a repeatability for each data point of 0.1% of the range of the analog scanner, with the exception of the O_2 analysis and the hand-set items. The repeatability used in evaluating the computed results are listed in Table II.

Computing Methods & Results

The data were processed on the ElectroData Computer (Datatron) located in The Babcock & Wilcox Company computer section in New York. This is a stored-program, magnetic-drum, electronic digital

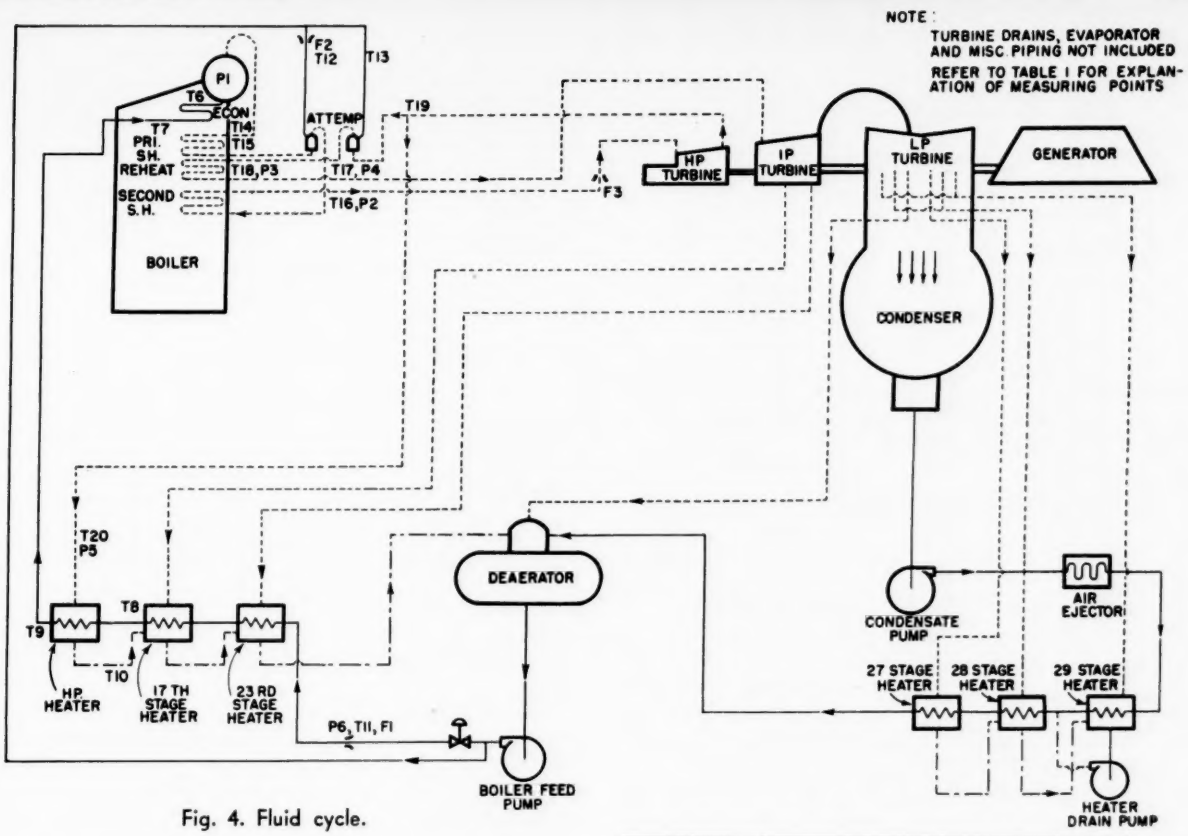


Fig. 4. Fluid cycle.

computer with an internal storage of 4000, ten-digit words and 400,000 ten-digit words of auxiliary storage on magnetic tapes.

In order that the computer program remain reasonable in length, no provision was made for applying correction factors to the data. This was justified since the principal object was to establish the stability of the data taking system and the ability to detect changes in boiler conditions.

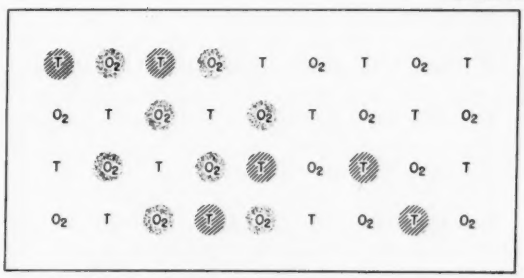
Two computer output forms were used: (1) controlled format on the Flexowriter as a result summary, and (2) a punched paper tape containing the major results and some intermediate results. The punched tape was converted from computer code to teletype code for transmission to Springdale. Fig. 6 is an example of the Flexowriter output; Fig. 7 is an example of how the data and results appear in a teletype printout; Fig. 8 shows the overlays used to read the teletype printout. The major results calculated from the DATAK data obtained at Springdale are:

A. Boiler Efficiency
B. Heat Absorption
C. Gas Temperatures
D. Tube Bank Conductances

Examples of these results obtained during a 24-hour period are given in Fig. 9. The turbine was operating with the control valves in a fixed position to establish a constant load on the boiler. The soot blowers were operated in stages starting from the bottom and working to the top of the convection pass.

Boiler Efficiency

Boiler efficiency was calculated using the heat loss method. The exit flue gas temperature, O_2 analysis,



O_2 - GAS SAMPLES: TWO PER PROBE FEED COMMON LINE, 9 SAMPLES
T - THERMOCOUPLES: TWO PER PROBE, 18 THERMOCOUPLES
AVERAGE OF CIRCLED POINTS EQUIVALENT TO AVERAGE OF COMPLETE MATRIX

Fig. 5. Configuration of air-heater outlet matrices.

Table II—Repeatability of Data Used in Calculations

All gas, air and water temperatures	0.4°F
All steam temperatures	0.6°F
Drum and Superheater Outlet Pressure	1.0 psi
Extraction steam, Reheater in and out pressure	0.4 psi
Feedwater Pressure	2.0 psi
Feedwater Flow	1200#/hr
O_2 Analysis	0.05%O_2

Hand Set Items:
Repeatability Given in Units of Parameter

Moisture in air	0.024 lb H_2O/lb dry air
Unaccounted losses	0.024 % Efficiency
Radiation loss	0.0024 % Efficiency
% Carbon in fuel	0.05 % Analysis
% H_2 in fuel	0.05 % Analysis
%O_2 in fuel	0.05 % Analysis
%S in fuel	0.05 % Analysis
% Ash in fuel	0.05 % Analysis
%H_2O in fuel	0.05 % Analysis
H.H.V.	50.00 Btu/lb
% Carbon in Ash	0.05 % Analysis

```
4          TEST NUMBER
9- 8-56    TEST DATE
1330       TEST START TIME

523.8  526.1  510.5  503.0          TEMPERATURE
525.5  516.7  496.9  504.3            OF AIR
530.0  507.6  491.3  495.2       LEAVING AIR HEATER
510.7

310.7  323.1
297.0  286.2
262.6  284.2
258 3  257.7                     TEMPERATURE
240.5  242.5                       OF GAS
248.8  244.8                 LEAVING AIR HEATER
245.8  257.3
280.0  270.5
261.9  299.9
270.6

579.1  544.0  560.5  571.9  558.9  556.3   TEMPERATURE
576.2  558.6  565.1  562.8  573.2  566.7     OF GAS
702.7  684.1  649.2  676.3  642.9  613.0  LEAVING ECONOMIZER
596.7

USED IN CALCULATION:      CONTRACT      FUEL ANALYSIS, AF
      5.96                  6.00            MOISTURE, %
     15.95                                  ASH, %
      2.02                                  SULFUR, %
      4.36                  4.50            HYDROGEN, %
```

Fig. 6. Example of Flexowriter output.

```
02013001037                                  01160140
02908003913                                  00617294
01576000658                                  00735654
01717002124                                  00013221
01010001907        (a)          (b)          01022711
05425001526                                  00016130
00677001669       DATA        RESULTS        01430172
02134001006                                  00016766
01933003492                                  01862302
01511000706                                  00015985
01687002173                                  00545441
```

Fig. 7. Teletype output.

```
AIR HTR AIR OUT              101 |  | 201 AIR HTR GAS OUT
ECONOMIZER GAS OUT           301 |  | 401 ECONOMIZER GAS IN
ECON WTR OUT, N              501 |  | 601 SPRHTER ATT IN, N
DRUM PRESSURE                701 |  | 102 AIR HTR AIR OUT
AIR HTR GAS OUT              202 |  | 302 ECONOMIZER GAS OUT
ECONOMIZER GAS IN            402 |  | 502 ECON WTR OUT, S
SPRHTR ATT IN, S             602 |  | 702 SPRHTR OUT PRESS
AIR HTR AIR OUT              103 |  | 203 AIRHTR GAS OUT
ECONOMIZER GAS OUT           303 |  | 403 ECONOMIZER GAS IN
ECON WTR IN, N               503 |  | 603 SPRHTR ATT OUT, N
REHEATER IN PRESS-           703 |  | 104 AIR HTR AIR OUT
```

Fig. 8. Overlay used to read Teletype data.

and the entering air temperature were measured, all other necessary information was entered as hand-set items. Obviously the correct fuel analysis could not have been preset and values representing what could be expected from the coal source were used.

The validity of determining boiler efficiency in this manner may be readily established. The losses due to dry gas, moisture in the fuel, and hydrogen in the fuel constitute something on the order of 80% of the losses. The remaining 20% result from CO in the flue gas, combustibles in the refuse, radiation, sensible heat in the refuse, unburned hydrocarbons, moisture in the air, etc. Because the losses represent about 10% of the heat input, a 1% error in determining losses results in a 0.1% error in determination of efficiency.

The losses due to dry gas, moisture in the fuel, and hydrogen in the fuel (about 80% of the losses) are calculated from current data and expected fuel analysis. The remaining losses are entered from a knowledge of past history and expected fuel analysis. Past history furnished the radiation losses, an agreed-upon "unaccounted loss," and the combustibles in the refuse. Of these, only the unburned combustibles are subject to variation.

Table III illustrates the effect of using hand-set items. Boiler efficiency was calculated using three different fuels and assuming the same values for total air, exit gas temperature, and inlet air temperature. Fuel A and Fuel B represent two coals quite different in analysis. Fuel F is a fictitious fuel having an analysis which is the average of A and B. If Fuel A was being burned but the analysis for Fuel F was used in calculating the efficiency, a 1.23% error would result. If Fuel B was being fired, a 1.12% error in the other direction would result.

The "repeatability" in the boiler efficiency calculation resulting from the use of DATAK data (exclusive of the question of obtaining representative flue gas conditions, and the use of preset values of fuel analysis) is about 0.16%.

The heat absorbed in each section of the convection pass was calculated using fluid temperature and pressure measurements at the inlet and outlet of each section.

The gas weight passing through the convection pass was determined by heat balance around the economizer.

With the exception of the boiler efficiency, the calculated results show variations greater than would be caused by mechanical imperfections in the data. This is particularly true of the gas temperatures and the conductances in which trends are hard to find. Possibly the best explanation of these variations is found in two thoughts. First, in spite of the so-called steady-state operation established by the fixed turbine-control valves, the various portions of the boiler are in a continuous state of change about some mean value. Our quick look at the boiler catches these excursions at various points in their departure from the norm. Secondly, because a finite time is required for collecting all the data, and because the variables can change at different rates, the true relative values are not obtained. This may accentuate or diminish any given excursion of any particular calculated value from the norm.

It is significant that results of this quality were obtained with equipment of high-grade commercial quality. The implication is that it is not necessary to invest in equipment of laboratory precision to obtain consistent results with low dispersion. Thus, it is possible to test with a relatively low-cost system and determine the changes in the various aspects of boiler performance. The absolute accuracy must be established by a full-scale manual test using calibrated flow nozzles, orifices, etc. Thereafter, the automatic data-collecting equipment is used to measure the departure from this reference condition.

The significance of this possibility deserves careful consideration when contemplating the use of automatic data collecting equipment.

General Comments

DATAK can obtain all temperature, pressure, flow and draft data on a boiler and turbine in about 3

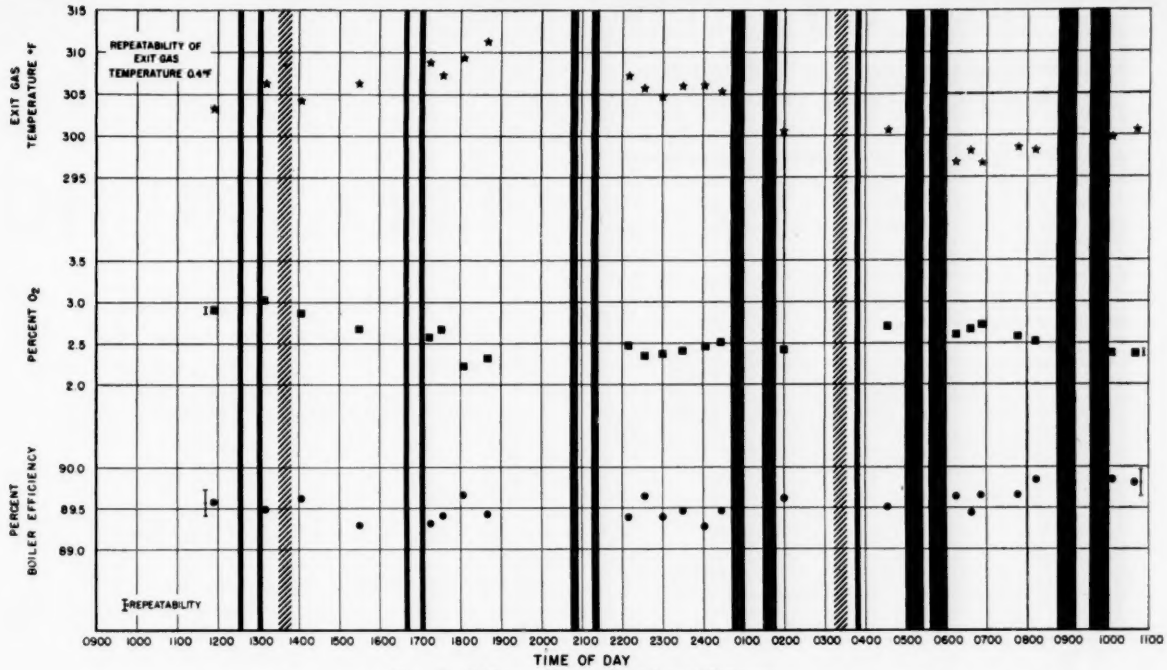


Fig. 9. 24-hour test of boiler efficiency.

minutes. O_2 analysis requires another 1 minute per point sampled. Manual means require considerably longer for collecting the same amount of data. This speed of data collecting opens the possibility for taking "snapshots" of the unit rather than time exposures, and thus the opportunity to study operation in a new manner. Heretofore, it has been necessary to deal with time averages over a period of time on the order of an hour or more. Now it is possible to substantially reduce this averaging period.

DATAK, as built for this installation, will analyze nine flue gas samples in nine minutes, three times an hour, for as long a period as desired. A man with an orsat could analyze nine samples in one hour for the first few hours, after which he would need relief. DATAK reads temperatures, pressures, etc. at the rate of one a second, or faster, and does not tire. It would be very difficult to match this performance with men.

Contrast the machine and man doing the same job. The machine has high initial cost, but lower operating cost. The machine is faster and more consistent. The machine does not tire and hence the data at 3:00 a.m. are as good as the data at 10:00 a.m.

Two important areas for consideration concerning the use of this type of equipment have been presented here. The first and most obvious is the direct replacement of testing manpower, particularly cogent on a unit of radical design or a more conventional unit in serious trouble. The second and more subtle is the possibility for new testing concepts based on a "snapshot" of the unit rather than a time exposure. This is the real value of DATAK, as a new tool to explore the operation of steam electric generating units in a new way.

Analog records of a few unit parameters may be used as guides to determine the opportune time for taking the snapshot. In this way, the digital technique supplements the analog record to give a more detailed picture than is economically feasible, time and cost-wise, with all analog data.

Table III Effect of Fuel Analysis on Boiler Efficiency

	Fuel A	Fuel B	Fuel F
H.H.V.	14,550	10,950	12,750
% C	83.53	60.65	72.09
% H_2	4.35	4.09	4.22
% H_2O	2.50	12.00	7.25
% O_2	2.14	6.00	4.07
% S	0.74	4.10	2.42
% Ash	5.00	12.00	8.50
% N_2	1.74	1.16	1.45
% Efficiency	88.75	86.40	87.52

Assumed: Total air 116.2%
Exit gas temperature ..... 360.0 F
Entering air temperature ..... 60.0 F
Carbon in refuse 4.0%

The exploration of the new possibilities for boiler and turbine studies has hardly kept pace with the development of automatic digital data-collecting equipment, and yet here lies the possibility for a significant contribution to the field of electric power generation. The industry has reached a point of diminishing returns in increasing the initial conditions of temperature and pressure. Today's search for lower heat rates may well be facilitated by new instrumentation concepts based on digital techniques. Equipment like DATAK, continuously coupled to a computer, might be monitoring the performance of a large unit to narrow the gap between the design heat rate and that generally achieved in operation.

This is largely the province of the users, to take advantage of the opportunity for a new and different look at their units and by this means point the way toward improved boilers, turbines, controls, and instrumentation.

ELECTRONIC

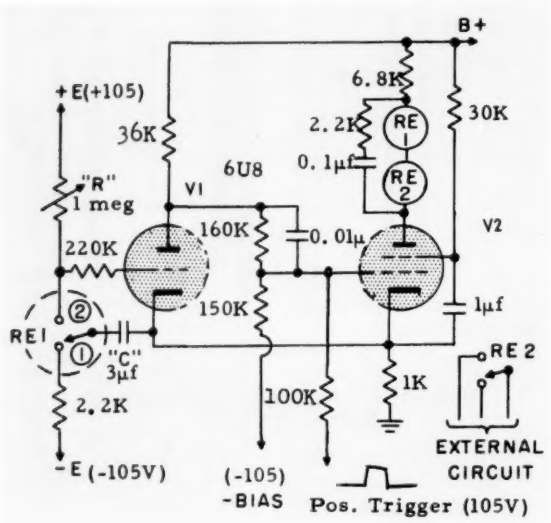
MILTON H. ARONSON
Instruments & Automation

and

CHARLES F. KEZER
Key Electric Corp.

HIGHLY STABLE TIME-DELAY CIRCUIT USES MODIFIED SCHMITT TRIGGER

A precision time-delay circuit has been developed in connection with a Bevatron magnet-timing equipment. The operating conditions required a circuit with a stability of at least 1 part in 1000 over a delay range of 150 milliseconds to 2.5 seconds. The circuit has a lower limit of 3 milliseconds and an indefinite upper limit (restricted only by the maximum value of timing capacitor used). The circuit also provides relay contacts for external use if desired.



The circuit used is a modified form of Schmitt trigger. Tube is a 6U8 triode-pentode.

In the rest state, V1 is conducting, V2 is cut off, and "C" is charged to —E (relay position No. 1). The start of the timing cycle occurs when the positive 105-v trigger is applied to grid of V2. This causes a positive signal at the common cathode, and a still larger positive signal at plate of V1. This regenerative action causes the pentode to conduct fully and immediately, causing RE1 to swing to position 2.

When RE1 swings to position 2, the negative charge on C cuts of V1, and V2 conducts. C now charges positively through R (toward +E) until the grid just passes the cutoff voltage. At this time the Schmitt-type regenerative action again occurs and quickly causes the pentode to cut off, restoring the circuit to its rest position, and ending the time cycle.

Note that both +E and —E are of equal value. Therefore, if +E and —E vary together, the timing accuracy is not materially affected. This voltage is most easily obtained by grounding the center tap of a regulated supply.

The Bevatron magnet pulse-timing equipment uses two such circuits; one has a variable range of 0.15 sec to 2.5 sec (time of rectification cycle), and a 2.5-sec lockout circuit to insure that a particular repetition rate is not exceeded.

Time delay: With R of 1 meg and C of 3 uf (as shown), time delay is 0.15 to 2.0 sec.

Stability: Both circuits have operated for 1 1/2 years with a long-term stability of better than 1 part in 1,000. The jitter (from cycle to cycle) is less than 1 part in 2,000.

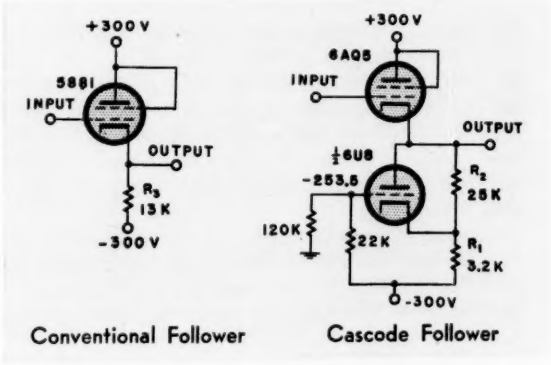
B Supply: +250 v at 12 ma or 8 ma, depending on which side is conducting. Relay side draws 12 ma; ±105-v supplies should be regulated by VR105's for best stability.

Relays: RE1 and RE2 are Western Electric 275C relays.

Source: Warren C. Struven, Radiation Laboratory, U. of Cal., Berkeley, Calif. This work was performed under the auspices of the U. S. Atomic Energy Commission.

CASCODE CATHODE-FOLLOWER MINIMIZES HEAT DISSIPATION

This amplifier is used as the output stage of an analog computer amplifier, delivering output swings of ±100 v across a 6.67K-ohm load, corresponding to load currents of ±15 ma. Because many of these amplifiers are packed into one computer, it is desirable to minimize both size and heat dissipation. Use of this circuit provides a one-third reduction in heat dissipated in the tube and circuit



components over that obtained with the conventional cathode follower circuit, and at the same time permits the use of miniature tubes.

Using the same supply voltages as the circuit shown, the conventional cathode follower output stage would require a large tube such as the 5881 (6L6 equivalent) with a 13K-ohm cathode resistor. This resistor value is chosen as the one which passes —15 ma through the 6.67K-ohm load with the tube practically cut off, to develop full negative 100-v output. When the cathode follower is developing +100-v output, the tube must pass the 15-ma load current plus the current then flowing in the 13K-ohm resistor. As the voltage across the 13K-ohm resistor is 400 v when the output is at +100 v, the total current which the tube must pass is 46 ma.

CIRCUITRY

The circuit is the heart of all electronics. Here are 3 more basic and interesting circuits. Unless marked, resistors are in ohms, capacitors in microfarads.

Plate dissipation of the triode-connected 5881 is then 9.2 watts; 12 watts is dissipated in the cathode resistor, and 5.6 watts are dissipated by the tube heaters, for a total of 26.8 watts.

If the cathode resistor were replaced by a tube connected to maintain practically constant plate current, power dissipation could be substantially reduced, as the upper tube need pass a maximum plate current of only a little more than 30 ma. This reduction in current results from eliminating the increase in cathode resistor current from 15 to 31 ma as the output changes from −100 to +100 v. Normally, however, this constant-current cathode-load tube must be a power tube, capable of several watts plate dissipation. In the circuit shown, the cathode load is made up of resistors in combination with a low-power tube (½ of a type 6U8); resistors handle most of the power. Only 1.37 watts is dissipated by the 6U8 tube plate.

Grid of the 6U8 triode is held at a fixed potential of −253.5 v by the 22K-120K voltage divider. A portion of the output voltage is applied to the cathode of the 6U8 tube via the voltage divider R1-R2; as the grid potential is held fixed, the grid-cathode potential depends on the voltage at the cathode.

When the plate-cathode voltage of the 6U8 tube is high, as at +100 v output, the tendency of the tube to draw higher plate current is overpowered by the increase in cathode voltage via the divider R1-R2. Thus at increased output voltages, the *decreased* current in the 6U8 tube nearly offsets the increased currents in the resistors R1 and R2. The combined currents of the resistors and tube thus present a nearly constant-current cathode-load to the 6AQ5 tube. This permits the 6AQ5 to be operated with maximum plate current of only 33 ma, and a correspondingly low plate dissipation.

Maximum heat dissipation of the circuit, including plate and heater dissipation of both tubes and the power dissipated in the two resistors, occurs at +100 v output, and is 18 watts. This is a reduction of over 8.5 watts from what is obtained with the conventional cathode follower stage described above.

Operating currents and voltages are tabulated below for output voltages of 0, +100 v and −100 v. I_1 is current in R_1; I_2 in R_2

E_o (v)	I_1 (ma)	I_2 (ma)	6U8 I_p (ma)	6U8 E_k (v)	6U8 E_{gk} (v)	6U8 E_{pk} (v)	6AQ5 I_p (ma)
0	16.4	9.9	6.5	−247.5	−6	247.5	16.4
+100	17.6	13.7	3.9	−243.5	−10	343.5	32.6
−100	15.1	6.0	9.1	−251.5	−2	151.5	0.1

Input: −150 to +88 v dc for full output.

Output: ±100 v across 6.67K-ohm load (±15 ma load current).

Gain: 0.82 (approx.)

Frequency response: Depends on capacitive reactance of load.

Output impedance: Varies with signal level, 400 ohms average.

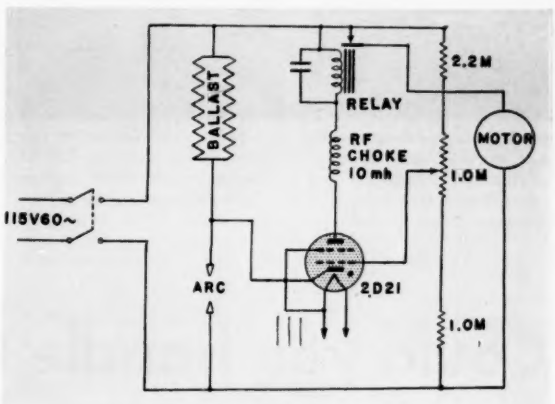
Power supply: 300 v dc at 33 ma max with 6.67K load; −300 v dc at 19 ma max. Supply current depends on signal level.

Source: James H. Doyle, Weber Aircraft Corporation, Burbank, Calif.; also *Electronic Design*, April 1, 1956.

ARC-LAMP ELECTRODE CONTROL MAINTAINS CONSTANT ARC CURRENT

Current across the arc of an arc lamp must be held constant for uniform illumination. A ballast resistor is placed in series with the carbon electrodes in this circuit to limit current and to stabilize the arc. For steady line voltage and fixed ballast resistor, the arc current depends only on arc spacing. This circuit is designed to control and maintain the arc spacing, and hence the arc current.

Arcs have a negative voltage-current characteristic. (This characteristic was used in the earliest r-f sources, which were tuned tanks placed across arcs.) When the arc current is reduced, voltage across the arc increases,



and vice versa. The 2D21 thyratron senses arc voltage and controls the carbon feed motor as follows: As the arc burns the carbon away, current decreases and voltage increases. This positive arc voltage is applied to the cathode of the thyratron, which eventually becomes nonconductive as the arc voltage increases. When the thyratron stops firing on alternate half cycles, the plate relay completes the motor circuit, which drives a carbon-feed mechanism to reduce the arc spacing, thereby increasing arc current to its desired value and decreasing the arc voltage. At this point the thyratron again fires on alternate half cycles (because the plate is energized from the a-c line), which causes the plate relay to break the circuit to the carbon-feed-drive motor.

Arc spacing is adjustable with the 1-megohm potentiometer, which controls the d-c potential of the 2D21 grid. Capacitor across relay prevents relay chattering.

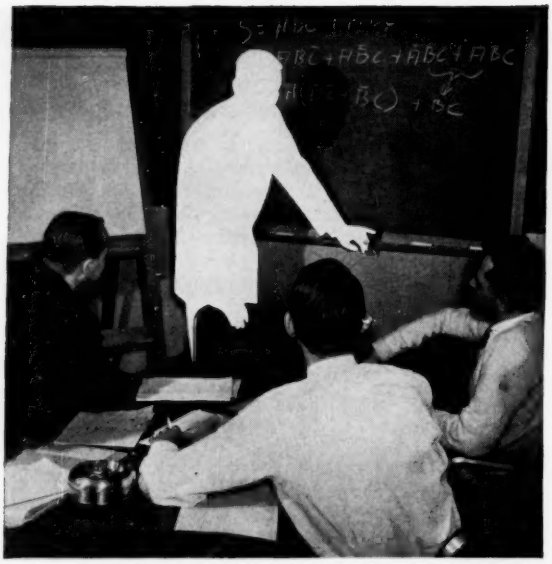
A slow-speed motor or one with a built-in brake is required to prevent coasting and overshoot.

Relay: Potter & Brumfield LM-5 with 5000-ohm-coil, 22.4-v dc.

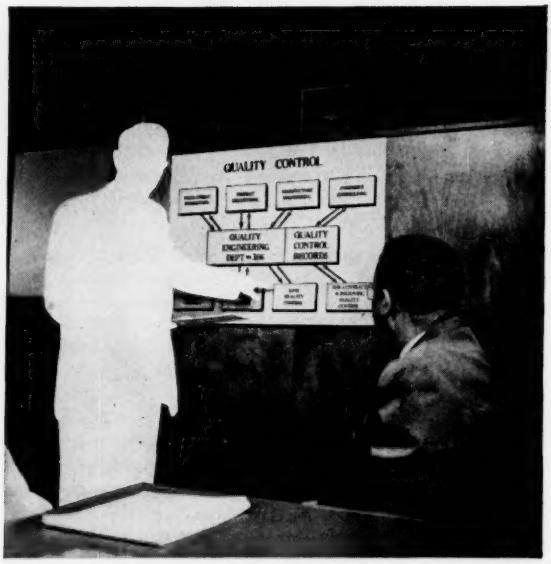
Supply: 6.3 v at 0.7 amp for 2D21 filament; about 700 watts is dissipated in ballast resistor.

Source: R. W. Romer, Bausch & Lomb Optical Co., Rochester 2, N. Y.; also *Electrical Manufacturing*, July, 1955.

IBM GROWTH promoted these men



Computer Logical Design Engineer: Before his recent promotion, this man was responsible for determining the broad systems outline of an electronic computer and its interconnection with external equipment. "In this job," he says, "you tailor such characteristics as computer speed, memory, size and arithmetic structure to the requirements of the computer system." He maintained close liaison with mathematical support, circuit designers, packaging and test engineers.



Quality Control Engineer: Also promoted recently, this man worked in Manufacturing Engineering. He was responsible for the performance of IBM electronic computers and other business machines. "The problems of Quality Control in this company are endless—and fascinating," he says. "You may be concerned with transistors and cores . . . gaseous electronics . . . diffraction of alloys . . . reliability studies. *There's always something new*—in this new and progressive field!"

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Digital Automation—No. 20.

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and

SHIGERU OCHI
Bendix Computer Division
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Fig. 20-1. Bendix G-15D general-purpose computer plus DDA accessory. DDA (at right) uses portion of memory drum in main GP computer.

DIGITAL DIFFERENTIAL ANALYZERS

Here is the first clear and simple description of the principles and operation of the digital differential analyzer, the direct way to solve differential equations in engineering and scientific work. Although simple in both principle and operation, the power of the technique applies to all fields of engineering work—process, research, computation, aviation, education.

THE DIGITAL DIFFERENTIAL ANALYZER, or DDA, has found numerous applications in the field of engineering and control. Like the Bush mechanical differential analyzer and the electronic analog computer, its principal use is for solving differential equations. These equations may be those under study by a mathematician exploring the behavior of certain classes of differential equations; they may be those representing a physical system which is being simulated on the computer; or the digital differential analyzer can be adapted to a particular need.

The DDA is a special-purpose digital computer. A general-purpose computer can be programmed to solve any equation that can be handled on a DDA within the memory capacity and time requirements of the problem. In general, this requires the transformation of the equation into suitable arithmetic form by use of numerical analysis techniques, and then formulation of coded instructions for the computer. The programming time required is extensive and the programming knowledge required is specialized and often sophisticated. The DDA, on the other hand, can be programmed with the relative ease of an analog computer. As the solution is digital, however, much greater accuracy can be obtained on a DDA than on the analog machine. Further advantages of the DDA over the electronic analog computer are (1) nonlinear variables can be used as the independent variable of integration and (2) drift problems do not exist.

The program for a GP computer consists of many detailed setups telling the machine to obtain two pieces of data, perform a given operation on them, and store the result in a specific place. Whole numbers are transferred between the several operational units; time is consumed in searching for data and instructions. (However, computing is done in large increments and the actual computing rate can be very high.) The detailed program is not fixed in a general-purpose computer.

The digital differential analyzer, however, has a semifixed program especially designed for rapid solution

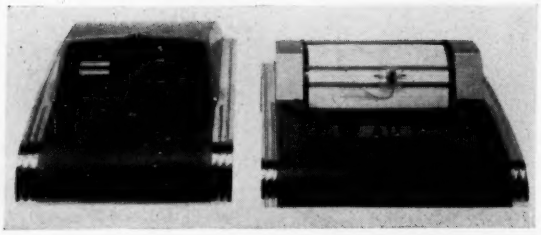


Fig. 20-2. "Litton 20" digital differential analyzer is compact.

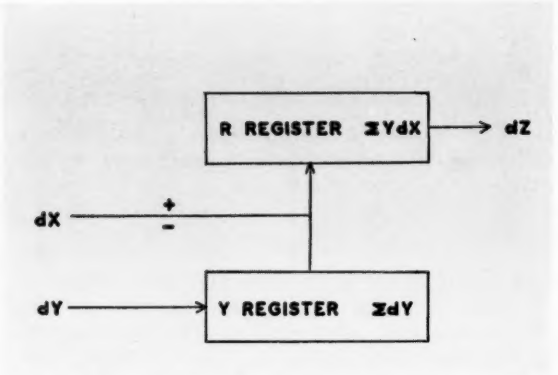


Fig. 20-3. Each integrator comprises one Y register (one channel on magnetic drum) which sums incremental Y inputs, and one R register (a second channel on magnetic drum) to sum the products of Y dX. An incremental Z output is produced only when the number in the R register exceed 1.0. Fractional values remain in the R register.

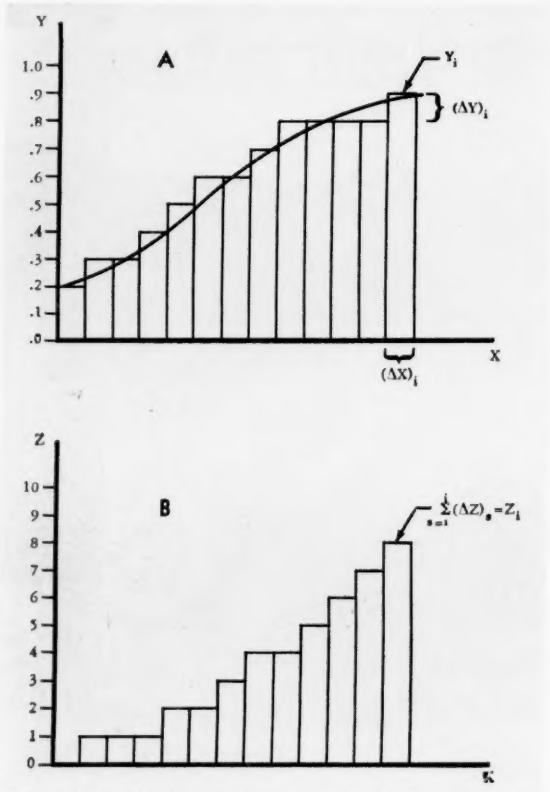


Fig. 20-4. The Y register sums the incremental Y inputs to develop the amplitude of Y at any given value of X. The R register develops the product Y dX, which is the area of one rectangle, and sums the areas until its contents exceed the value of 1.0. At this time an incremental dZ output occurs. Each dZ output has a value of 1.0 or some whole number. The dZ output can be summed (in a second integrator) to give Z, the area under the curve of Y, as shown in B. Table 20-1 gives actual values of numbers in the registers.

of differential equations. Unlike the whole-number operation of the GP computer, the DDA develops and uses *increments* of a variable, and is often referred to as an *incremental analyzer*. The arithmetic circuitry of the DDA is simple because (1) only summation (addition and storage) is performed and (2) each summation is performed serially, a bit at a time. As the program is semi-fixed, it is necessary only to determine how to connect the few operational units (much as an analog computer is connected), how to scale the problem, and how to insert the initial conditions into the magnetic drum storage.

The DDA has not yet met with the wide acceptance that the general-purpose computer enjoys because it solves only certain classes of problems. Thus, while problems suited to it can be solved with relative ease, installations which require a computer for all types of problems do not find a separate DDA justified. There is now available a DDA accessory to the Bendix G-15D General-Purpose Computer called the DA-1 (Fig. 20-1), which will enable differential equations to be programmed with the ease of a DDA. The DDA part of the operation uses a portion of the memory in the main general-purpose computer. The rest of the computer memory can be used for handling computations better suited for a general-purpose computer. Thus, with relatively little additional cost, the advantages of both the general-purpose computer and the DDA can be obtained. In a given problem, both types of operations can be performed simultaneously, resulting in greater versatility than possible with only a DDA. This discussion of the DDA will be based on the Bendix DA-1; other types of digital differential analyzers are available, such as shown in Fig. 20-2.

The main features of the DDA, which lead to its simplicity compared to the GP computer are (1) the arithmetic units are simple adder circuits, (2) only 1 bit at a time is read or operated on, (3) the program is semi-fixed in a predetermined manner, (4) only one storage device of relatively small capacity (a few hundred bits) is required.

A source of error that all digital machines have is *round-off error*. It will be seen that the DDA has a special form of this error due to remainders in the "R" register. It will be seen also that the DDA simulates differential equations by using an analog-type technique, which gives it its great efficiency in computation of continuous functions.

Table 20-1. Values of Numbers in Y register ($Y\Delta X$) and R register (R_i) of integrator 1 at successive intervals of X for curve shown in Fig. 20-4. The ΔZ outputs are summed in a second integrator, as shown in Fig. 20-6, to give output Z.

i	$Y_i\ (\Delta X)_i$	R_i	$(\Delta Z)_i$	$r_i = R_i - .5$	Z_i
0	————	0.5	————	0.0	0
1	0.2	0.7	0	0.2	0
2	0.3	0.0	+1	—0.5	1
3	0.3	0.3	0	—0.2	1
5	0.4	0.7	0	0.2	1
6	0.5	0.2	+1	—0.3	2
7	0.6	0.8	0	0.3	2
8	0.6	0.4	+1	—0.1	3
9	0.7	0.1	+1	—0.4	4
10	0.8	0.9	0	0.4	4
11	0.8	0.7	+1	0.2	5
12	0.8	0.5	+1	0.0	6
13	0.8	0.3	+1	—0.2	7
14	0.9	0.2	+1	—0.3	8

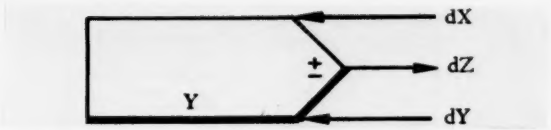


Fig. 20-5. Schematic representation of one integrator. The output dZ is Y dX, and can be plus or minus. The Y written in the block shows that the Y register simply contains Y, with no initial condition.

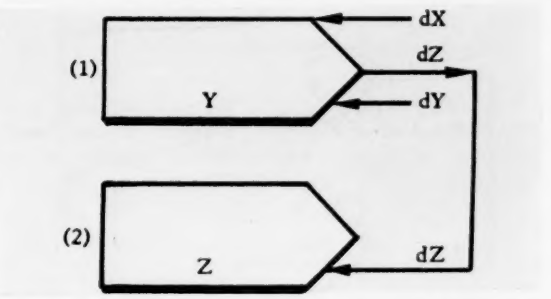


Fig. 20-6. Hookup of two integrators to solve equation $Z = \int Y\ dZ + Z_0$. Second integrator simply sums the dZ inputs to develop Z. Note Z is in the Y register of integrator 2, whose R integrator is not being used.

Elements of the DDA

A digital differential analyzer consists of a number of *integrators* (the basic element of the DDA). A fairly complex problem may require 10 to 40 integrators for its solution; a simple problem may require only 2 or 3 integrators.

One integrator is shown schematically in Fig. 20-3. It comprises two registers (which can be 2 channels on a magnetic drum) called the Y and R registers. It has 2 inputs to receive the independent (X) and dependent (Y) variable that define any function of two variables. The basic purpose of the integrator is to perform an integration of Y with respect to X. That is,

$$Z = \int Y\ dX$$

Note that this is simply a summation process for finding the area Z under the curve of Y (Fig. 20-4).

The Y register receives the dY inputs and sums them to give the amplitude of Y at any given time. (Note: the dY and dX increments referred to here are finite increments, and should rigorously be labeled ΔX and ΔY, but for convenience are referred to here as dX and dY.)

The R register receives both Y and dX inputs, and develops the product Y dX, which is the area of any one of the narrow rectangles in Fig. 20-4. It sums these incremental areas, but delivers an output dZ only when the sum stored in the R register exceeds a given value. Hence dZ represents the overflow of the R register.

X is permitted to change by only 1 increment in any given cycle. That is, dX can be 1, —1, or 0. Unlike X, Y can change by more than a single increment during any given cycle. The increments of Y shown in Fig. 20-4 are tenths; Y itself is restricted to $-1 < Y < +1$.

The R register receives the Y and dX signals and sums them, as mentioned previously. However, it also is restricted in value to $0 \leqslant R < +1$ so that only fractional portions of the sum are retained in the R register; the integral portions become a series of dZ outputs, each having a value of unity, as shown in B in Fig. 20-4.

Initial values can be given to both the Y register and the R register. In order to minimize the round-off error inherent in this overflow technique, the initial value of R is set at 0.5 so that the first dZ output will occur when Y dX exceeds 0.5. Note that the number in the R register (the fractional portion of any one rectangular area in Fig. 20-4, A) always exceeds the true value by 0.5 unit.

Table 20-1 shows numerically how the DDA develops the Z curve of Fig. 20-4, which is the area under the Y curve, or the integral of the function Y. Note that at time 0 (i=0), the number in the R register is set to 0.5.

In the first dX interval (i=1), Y has a value of 0.2 and dX is 1. Hence Y dX is 0.2 plus 0.5, or 0.7. As the number in the R register is less than 1, there is no dZ output.

In the next interval, Y is 0.3, dX remains 1, Y dX is 0.3. The number in the R register is now 0.3 plus 0.7, or 1.0. Hence dZ increases by 1 unit and 0 remains in the R register.

In the third interval, Y remains at 0.3; dX is always 1; hence Y dX is 0.3. The number in the R register (R_3) now increases from 0 to 0.3. There is no dZ output.

In the fourth interval, Y becomes 0.4; R_4 becomes 0.7; dZ remains 0.

In the fifth interval, Y becomes 0.5; Y dX is 0.5; R_5 becomes 1.2—but only 0.2 remains as R_5 with dZ receiving the spillover number 1.

The area under the curve of Y, or the integral of Y dX is thus developed in this manner. A second integrator is required to sum the dZ outputs to give the desired Z output, as shown in Fig. 20-6.

Examples of Integrator Interconnection

It may be helpful to introduce several simple examples illustrating the use of integrators in the solution of differential equations.

The schematic representation of an integrator is shown in Fig. 20-5. The relationship between the inputs and the output is:

$$dZ = Y\ dX$$

If the output of the integrator is made the secondary input to another integrator, the Y register of the second

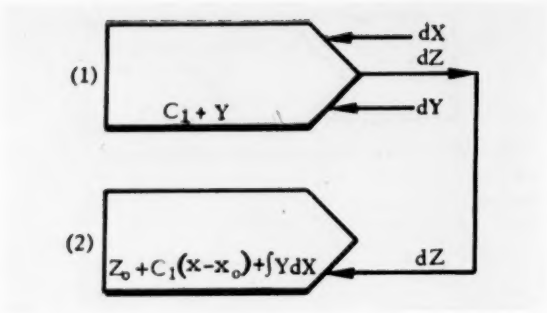


Fig. 20-7. Hookup to solve the same equation as in Fig. 20-6, but with initial conditions of C_1 for the Y register of the integrator 1, and Z_0 for the Y register of integrator 2.

Fig. 20-8. Only one integrator is needed to generate e^x because the derivative of e^x is e^x dX. That is, e^x must be in the Y register if the dZ output ($\int Ydx$) is the dY input because $\int e^x dX = e^x$.

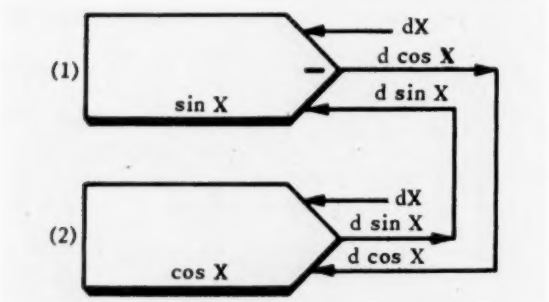


Fig. 20-9. Integrator connections for solving equation $Y'' + Y = 0$. Note that the Y register of integrator 1 must contain sin X, and that of integrator 2 must contain cos X to confirm the conditions shown—that is, that each dZ output be $\int Y\, dX$.

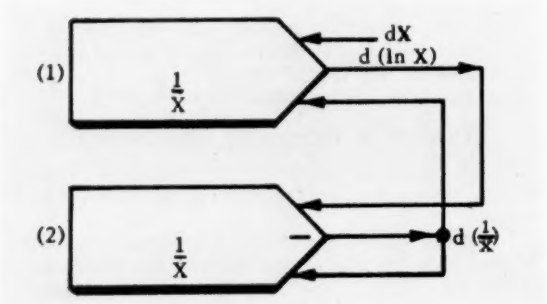


Fig. 20-10. DDA connections for generating 1/X. Here 1/X is in the Y register of both integrators.

integrator will accumulate the variable Z, as shown in Fig. 20-6. The operation of the two integrators is such that:

$$Z = \int_{x_0}^{x} Y\, dX + Z_0$$

where Z_0 is the initial condition of Z, and x_0 the initial condition of X.

Fig. 20-7 shows the more general case where:

$$Z = Z_0 + C_1 (X - X_0) + \int_{x_0}^{x} Y\, dX$$

Fig 20-8 illustrates the generation of exp X—i.e., the solution of:

$$Y' - Y = 0$$

As Y is e^x, $dY = e^x dX$, and the output of the integrator can be employed by the integrator as its own secondary input.

Fig. 20-9 illustrates the integrator interconnections for solving:

$$Y'' + Y = 0$$

in order to generate sine and cosine. The output of integrator (1) would normally be sin X dX, which is the same as $-d(\cos X)$. The minus sign at the point of the schematic of integrator (1), however, indicates that the sign of the output is reversed so as to yield $d(\cos X)$. With this as a secondary input, integrator (2) accumulates cos X. The output of (2) is cos X dX, which is exactly the required secondary input to integrator (1) —that is, $d(\sin X)$ Note that if the output sign reversal is removed from integrator (1), the hyperbolic functions sinh X and cosh X would be generated.

This programming technique of assuming the existance of a function (such as e^x or sin X) and then hooking up operational units in such a manner that the function must exist to satisfy the hookup, is the same technique as is used in analog computation.

The example shown in Fig. 20-10 illustrates the generation of 1/X. With dX as the primary input and 1/X as the integrand, the first integrator generates d(ln X). With this as its primary input, 1/X as its integrand and an output sign reversal, the second integrator generates:

$$(-1/X)\, d\,(\ln X) = (-1/X^2)\, dX = d\,(1/X)$$

which then becomes the secondary input to both integrators.

Fig. 20-11 shows the multiplication of two variables, U and V. The first integrator generates UdV, the second generates VdU, while the third integrator sums:

$$U\, dV + V dU = d(UV)$$

Typical Problems

In Fig. 20-12, the integral equation to be solved is given. Specifically, it is desired to know the value of A such that $y = 1$ at $x = 1$. The solution shown required use of 17 integrators.

It was known that A was approximately 0.3; this was used as the initial condition. Other initial conditions were that $x = 0$ at $y = 0.25$. Tabulated values of x (at $y = 1$) for various values of A were typed automatically, as shown at bottom right of Fig. 20-12.

y was maintained at a fixed value of 1. As each value of A was computed for a change in x, it was tabulated. After 6 tabulations, a larger change in x was ordered to obtain the solution more rapidly, as shown. Each computed and tabulated value is automatically reset into the computer to obtain the next computed value.

Note that as x approaches 1, an infinite discontinuity exists at the point $x = 1$ (which is the desired result). The final value for A at the solution point ($x = 1$; $y = 1$) is approximately 0.2563.

The associated graph plotter can plot the curve of

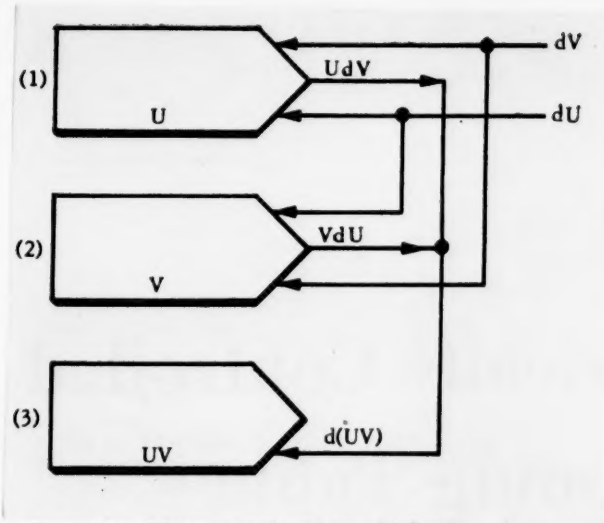


Fig. 20-11. DDA connection for multiplication of two variables U and V. The third integrator sums U dV and V dU, which is d (UV).

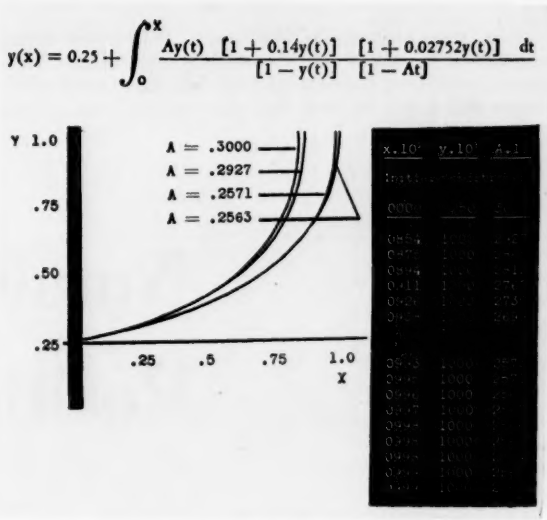


Fig. 20-12. Typical data output as automatically typed by the DDA in the solution of integral given, Curve is also automatically drawn.

y vs x at any given value of A. Four such curves are shown bottom left in Fig. 20-12. The one at the far right is the desired solution. It is of interest to note that the computer can handle certain problems with singularities or discontinuities.

Interation

Each integrator is an adder which adds increments of areas. The process is as follows: Information required for each integrator is placed on the memory drum. Information on the drum is read from the drum into the integrator and summing circuits, and the result is placed back on the drum. If there are 108 integrators, there are 108 positions on the drum for information. Each position is processed once per drum revolution; each processing is called an *iteration*. The speed of operation is 34 iterations per second.

General Characteristics

In addition to straight integration, the output of an integrator can usually be multiplied by some fixed constant. These integrators also can be used as "adders" and "decision integrators." As "adders," the integrators are used to sum the incremental changes of two functions. As "decision integrators," a wide variety of discontinuous and nonlinear functions, such as square waves, sawtooth waves, etc. can be generated. A special use of the "decision integrator" is as a "servo," whereby the integrator is programmed to continually make a correction that tends to reduce an error.

The setup of a problem on the DDA is similiar to that used on an analog computer. The highest-order derivative of the equation is frequently isolated from the others and assumed to exist. By repeated integration, the lower-ordered derivatives are obtained. The lower-ordered derivatives are combined according to the conditions of the equation to find the highest-order derivative. The resulting closed loop is mapped in a manner similiar to the hookups shown in Figs. 20-5 to 20-11.

Just as with the analog computer, proper scaling is necessary to keep the magnitude of the variables and the time scale at useful values. On a coding sheet, the initial value of each integrator, and the numbers of the integrators whose output is used as inputs to this integrator, are shown. This information is then entered into the computer, the input source depending on the particular DDA. In earlier models and in some equipments, the input is limited to manual control of keys on the control console. Later models, such as the Bendix D-12 and the G15D-DA1 combination, can read in punched paper tape or cards either for the initial problem or, at some given time in the computation, for later continuation of the solution.

Computation is usually started by a switch after the problem is entered. Resetting the initial conditions permits rerunning the problem. Variations in the parameters of the equation can be manually made from run to run, or the DDA can be programmed to automatically perform this operation. Where the DDA is used in conjunction with a general-purpose computer, even greater variations can be made.

The DDA is finding increasingly wide application in the solution of engineering problems. Control applications are many because ease of operation and simplicity of equipment are combined with excellent precision. The range of computation problems, both in the laboratory and in control applications, is being rapidly enhanced by DDA's, used alone and in conjunction with general-purpose computers.

Acknowledgement

This discussion is based on work prepared by Shigeru Ochi. Mr. Ochi wishes to turn to acknowledge contributions by L. S. Michels, R. M. Beck, M. Palevsky, and R. N. Goldman.

Table positioning is the most time-consuming operation in many metal-working operations. This tape-controlled numerical positioning system positions the table in two coordinates to 0.001 inch.

Numerically Controlled Positioning Table

BERNARD RESNICK Advance Industries, Inc.
and
MILES HAYES Jones & Lamson Machine Co.

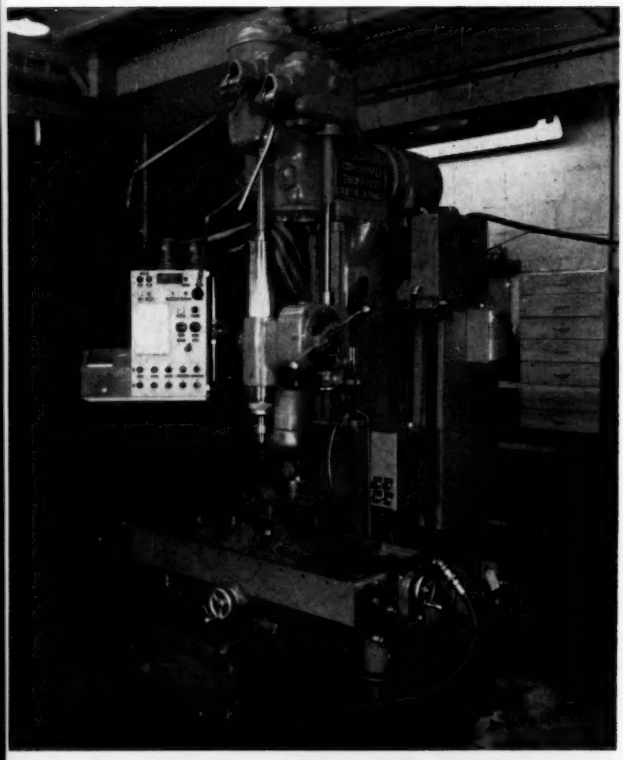


Fig. 1. Installation allows positioning work table quickly and automatically within 12" by 20" rectangle.

A NUMERICALLY CONTROLLED positioning table with two-stage hydraulic servo amplifiers permits workpieces to be automatically positioned to accuracy of 0.001 inch before being drilled. The machine consists of three major parts: (1) Positioning table proper consists of a work table on two sets of ways perpendicular to each other that position a workpiece anywhere in a horizontal plane with position-measuring lead screws and hydraulic power cylinders; (2) a standard Cincinnati-Bickford drill with manual controls is mounted above the positioning table; (3) a tape-reading electrical control system directs movement of the table to desired positions. The machine was built by the Jones & Lamson Machine Company; the tape-reading control system by Advance Industries, Inc.

The controls (Fig. 1, left) consist of a manual control box and a tape reader. One or the other is in control of the machine depending on position of a Manual-Tape switch on the box.

Positioning Table

The table positioning accuracy is 0.001" in the two orthogonal directions perpendicular to the drill. After positioning the table, the operator then operates the drill using manual controls to fix spindle speed, feed speed, and depth. After the operator raises the spindle, he pushes a button, whereupon the table moves the workpiece to the next location. The economic justification for such a machine is it (1) saves time and costly mistakes as compared with having the operator measure and position the workpiece manually, (2) saves set-up time as compared with positioning by setting

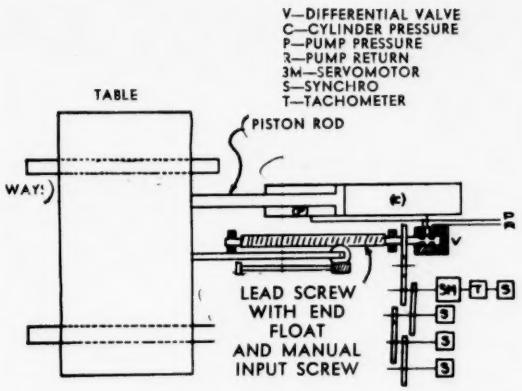


Fig. 2. Schematic of position control system shows lead screw, differential valve, and power cylinder that moves the table.

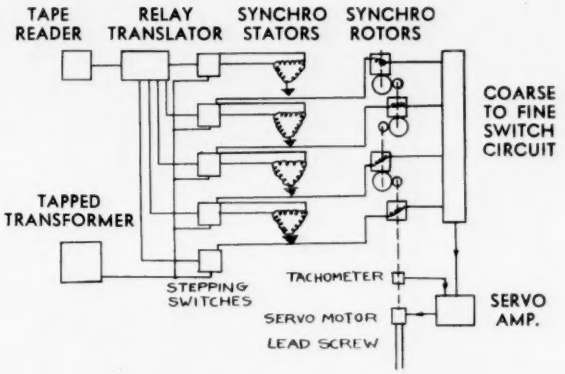


Fig. 3. Block diagram of control system for X (or Y) direction.

mechanical stops, (3) saves cost of jigs, and (4) permits flexibility for semi-automatic production in lot sizes as small as one piece.

The table moves 12 inches to and from the operator (Y axis), 20 inches to right and left (X axis), and has a floating reference point. Zero, or any other reference number within the 12″ x 20″ rectangle can be set as a reference point. This is done by setting in zeros (or other reference numbers) for X and Y on manual switches, and hand cranking the table position to the desired table reference point. This enables one to make a tape for a workpiece without worrying about where it is to be located on the table.

The table will only move forward and to the right from its zero point. These are the *positive directions*. It does not recognize or use negative numbers. Hence all operations must be made back of, or left of, the origin.

Hydraulic Servos

Each of the two movements, X and Y, is performed by a packaged servo and position-measuring system consisting of lead screw, hydraulic servo valve, and hydraulic piston. The lead screw is a position-measuring and controlling device only; it does not drive the carriage. Every angular position of the lead screw corresponds to some linear position of the carriage. When the lead screw is turned, a nut attached to the carriage at first remains stationary. Therefore, the lead screw makes a slight lengthwise movement. This increases (or decreases) the size of an oil-restricting orifice at the end of the lead screw, which causes the main hydraulic valve to admit or remove oil from one end of the hydraulic power cylinder whose piston moves the carriage in a direction to return the lead screw and valve to neutral (Fig. 2).

This system gives two stages of hydraulic power amplification. The power piston is controlled by the valve V; and valve V in turn is controlled by a small force and a small motion from the lead screw. The system is sensitive to lead screw movements of the order of 0.0001″ and a few inch-ounces of torque on the lead screw will produce several thousand pounds force on the carriage. Because the lead screw does not touch the valve but only a moving film of oil, there is no end wear, almost no load on the lead screw, no screw wear, and no backlash.

Electrical Control System

The electrical control system converts code on a punched tape into rotational position of the lead screw, which is then converted by the hydraulic servo into linear position of the carriage. The major steps performed by the electrical system are as follows:

A tape reader, consisting of electrical brushes, reads one line of tape (up to 26 holes), which gives desired position in inches to one-thousandth inch (5 digits).

The relay translator (Fig. 3) accepts the 5-digit signal from the tape reader and energizes appropriate relays. These in turn cause each of the five stepping switches to select any 1 of 10 possible positions on a tapped transformer. This causes the *field* of each synchro to be in one of ten possible orientations.

As in any synchro, the rotor will have a signal induced in it unless it lies in the same direction as that of the field induced by the stator winding. Hence, there will be a signal induced in each rotor winding if that rotor is not in the position (of the possible 10 positions) called for by the signal from the tape.

The synchro rotors are geared to the lead screw so that 0.1″ motion of the table equals 360° rotation of the finest synchro; 1″ motion equals 360° rotation of the next finest synchro rotor; 10″ motion equals 360° rotation of the coarse synchro rotor.

The signal from the coarse synchro is first sent to the amplifier via the coarse-to-fine switch circuit. This causes the table to be positioned within 10 inches. Next the signal from the medium synchro is sent to the amplifier; causing the table to be positioned with-

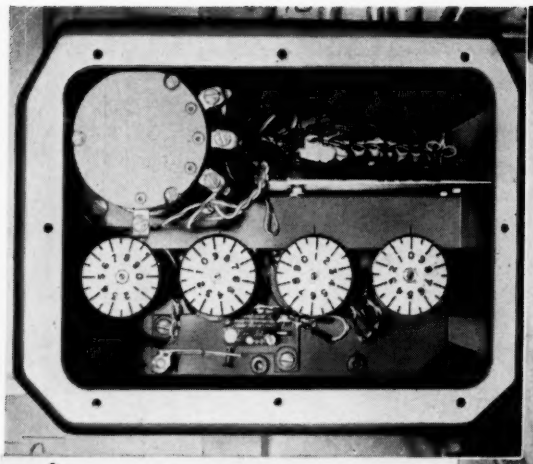


Fig. 4. Four synchros control position to tens, units, tenths, and hundredths, respectively.

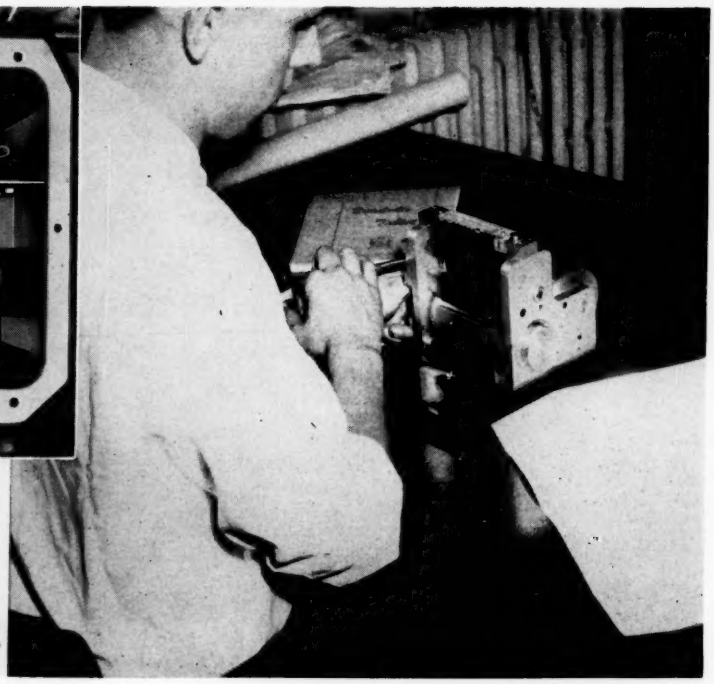


Fig. 5. Tape punch unit.

in 1.0 inch; the next synchro causes the table to be positioned within 0.1″; the finest synchro within 0.01″.

Note that the stator field of any one synchro calls for 1 *of* 10 *possible positions. Note also that the rotor of each synchro receives a signal from the next lower channel, which in effect is the next least-significant-digit position signal.* In effect, this divides each 36-degree sector (already established by the stator field) into 10 positions. In other words, the rotor of the second synchro in Fig. 3 will have zero signal induced in it only when (1) it lies in the 36-degree sector called for by its stator and (2) when it lies in the 3.6-degree sector called for by the next-least-significant channel. This permits positioning to within 0.001″ with four synchros and five stepping switches, as shown. It also provides overlap between digits so ambiguity is impossible.

6. The coarse synchro output is sent to the servo amplifier only if its error signal is significantly large. Otherwise, the medium coarse output is selected, if large enough, and so on. This is accomplished by putting one input through a nonlinear resistance composed of two rectifiers back-to-back, and comparing it with the finer input through a linear resistance. If the coarse signal is large it is selected; if small it is rejected.

7. The selected rotor output, representing the error signal, is sent through a vacuum-tube servo amplifier to a servo motor geared to the lead screw, driving the lead screw home to the desired position. A tachometer on the same shaft as the servo motor stabilizes the servo amplifier.

Tape

The tape is a 4″ wide perforated strip of Mylan with space for 32 holes to be read in parallel at one time. It is punched by means of a simple hand punch shown in Fig. 5. All tapes are prepared away from the machine so there is no interference with drilling operations. Tapes are folded flat and filed away until needed. It takes a programmer about 5 minutes per drilled hole, on the average, to prepare a tape.

An average tape contains 50 lines and makes a loop with 1-foot diameter. The longest tape which has been needed so far had 370 lines. This was for a workpiece which required 63 holes with several operations on each hole.

Drill Controls

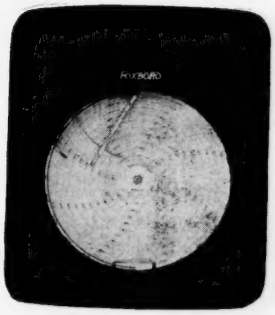
Drill controls are manual and conventional, consisting of a spindle speed selector, feed rate selector, combined manual and automatic control handle for depth of feed, and a forward-neutral-reverse lever.

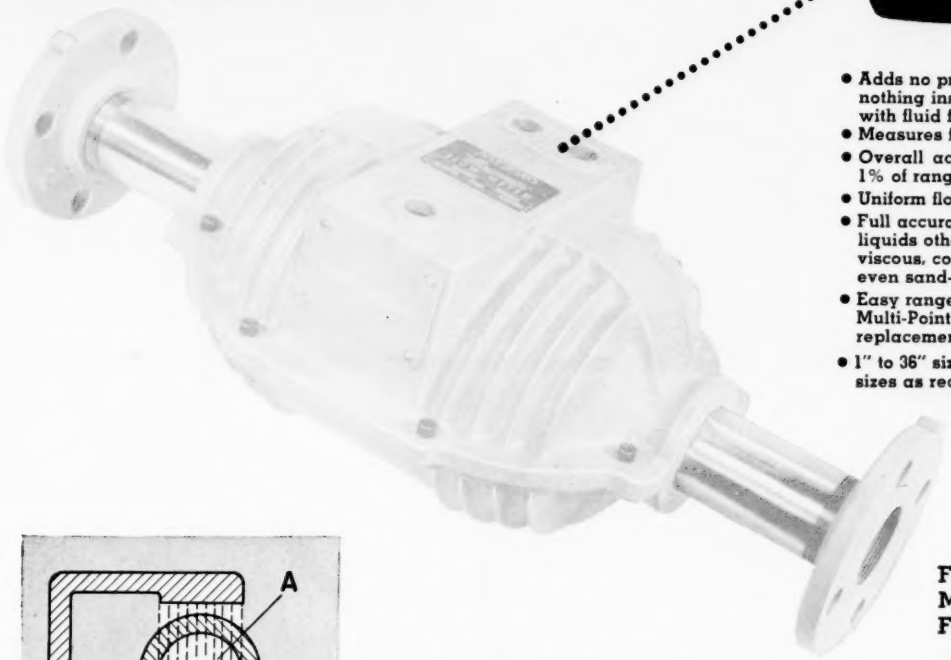
No attempt has been made to put drill controls or "Magic Chuck" under tape control, but it would be relatively simple, thus making drilling and drill-changing fully automatic. Positioning under the drill, the most time-consuming operation, is best suited for automatic tape control.

Conclusion

This machine appears to fill a rather simple but basic need in industry; namely, to quickly and automatically position a workpiece to an accuracy of ± 0.001″ without jigs, and to do this economically with any lot size down to a single piece.

Now! a flow meter with no flow restrictions!





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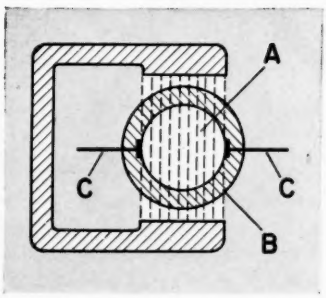

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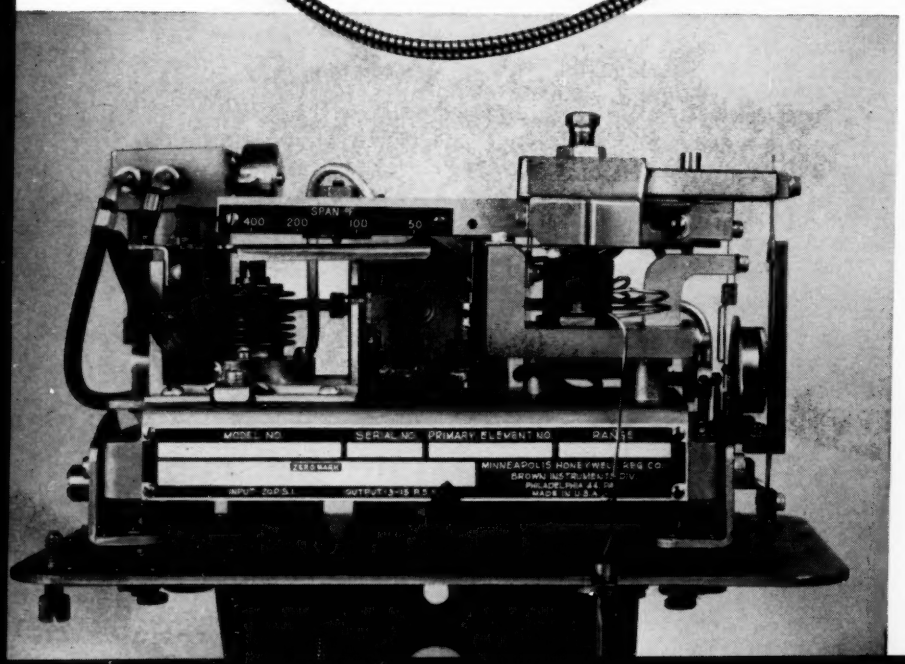

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You can arrange to have a Honeywell service engineer visit your plant at regular intervals to inspect, clean, and adjust your instruments and controls. He's factory-trained and field-experienced in keeping good instruments in top operating condition. If an emergency should arise, a phone call will bring a Honeywell service engineer to your plant in a hurry.

Spare parts, in a rush

A Honeywell branch office near you can be your storeroom for standard parts . . . in addition, the Parts Depot in Philadelphia carries a complete stock of all normally used parts. With Honeywell stocking your spare parts, you save storage and inventory control costs. Most shipments are made within 24 hours after orders are received.

Service is the

Practical service training

The tuition-free Honeywell Training School teaches your instrument technicians the most up-to-date maintenance methods, fits them for the kind of problems they may encounter on the job. Intensive courses range from two to fourteen weeks.

Application engineering

Experienced Honeywell application engineers know your industry and processes. They design *complete* systems of instrumentation, reducing the work of your own engineering staff. From the broad Honeywell line, they recommend instruments that are exactly right for the job. And because Honeywell supplies all types of instruments, recommendations are made without bias. Service engineers will, if needed, help with installation and startup of your system.

big extra you get with Honeywell instrumentation

Honeywell offers you far more than instruments. You get service whenever and wherever you need it . . . service that begins when you first decide you need instruments, and continues long after they're installed. This service is always conveniently close at hand, for there are more than 110 Honeywell sales and service centers located strategically throughout the U. S. and Canada.

Prompt, competent service by nearby field specialists is an important plus-value of Honeywell instrumentation. Your local Honeywell sales engineer has all the facts on this service as it relates to your instrumentation needs. Give him a call . . . he's as near as your phone.

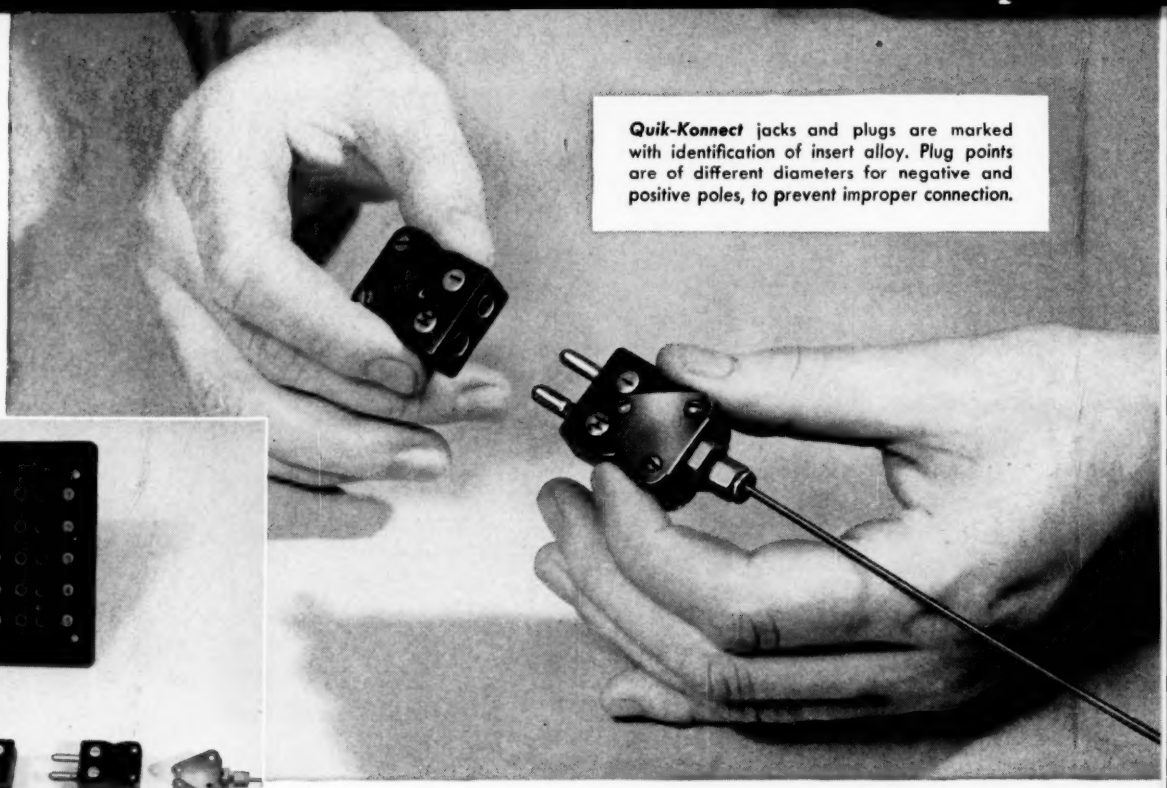
MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

H HONEYWELL

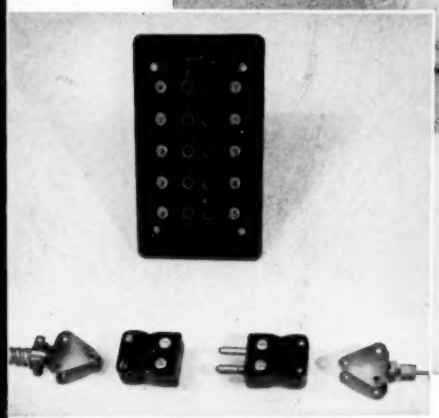
MINNEAPOLIS **Honeywell**

BROWN INSTRUMENTS

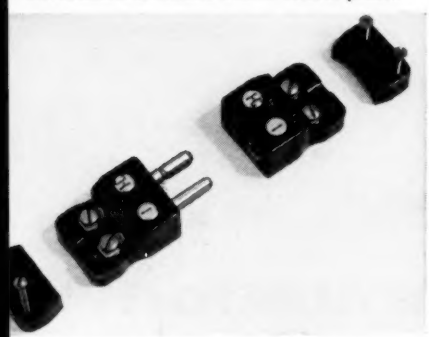
First in Controls



Quik-Konnect jacks and plugs are marked with identification of insert alloy. Plug points are of different diameters for negative and positive poles, to prevent improper connection.



The ***Quik-Konnect*** Components consist of (left to right) cable clamp, jack, plug, and tube connector, and (above) jack panel which can be mounted in conduit box or control panel.



Only the terminal cover at the rear of the connector need be removed during connection of wires.

Honeywell's new *Quik-Konnect** Thermocouple Components cut installation time 75%

. . . available through your HSM HONEYWELL SUPPLIES MAN

WITH these new *Quik-Konnect* Components you can make single, multiple or selective manual connection of a group of couples to an instrument. No handling of small parts. No confusing snarls of loose wire.

All assemblies are integral units. You can use them for quick extension wire connections in a laboratory or test cell, or for convenience and certainty of proper connections in permanent or semi-permanent installations.

Plug and jack assemblies have inserts or points made from the thermocouple alloys to which they should be connected. Available in four standard T/C combinations. For complete details, call your nearby HSM (Honeywell Supplies Man). He's as near as your phone; or write for S005-1 specification sheet.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

H HONEYWELL

MINNEAPOLIS **Honeywell**

BROWN INSTRUMENTS

First in Controls

*Trade name of Minneapolis-Honeywell Regulator Co.

new pressure switch

...has the appearance and performance you need

Looking for something new, something better, to control or limit the pressure of air, gas, oil? Use this new Honeywell Industrial Pressure Switch . . . designed to complement the most attractive equipment or panels . . . constructed to give lasting performance in the most rugged applications. Use it to make your equipment more automatic, improve your system, provide trouble-free service.

Here are the facts you'll want to know:

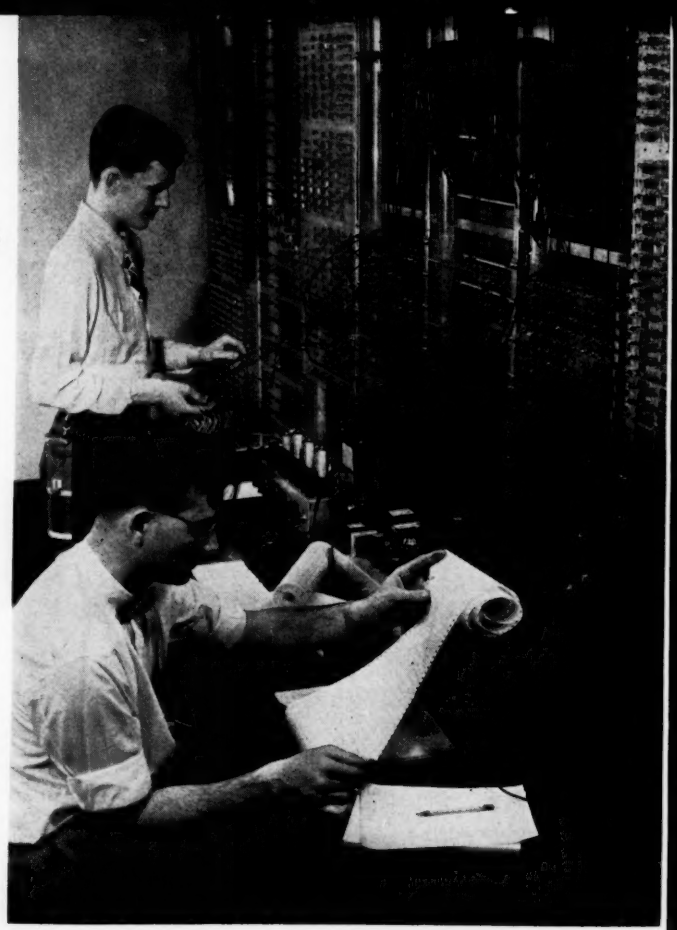
- Designed for flush or surface mounting
- Die-cast case is dust and corrosion resistant
- Visible mercury switch position (SPST or SPDT)
- Front-of-case set-point and differential adjustment
- Selection of pressure ranges to 3000 psi
- Specifically designed and constructed for industrial use . . . ½" pipe connection
- Available in explosion-proof construction

For complete data, a consultation on applications, prices for any quantity . . . get in touch with your local Honeywell sales engineer. He's as near as your phone. MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

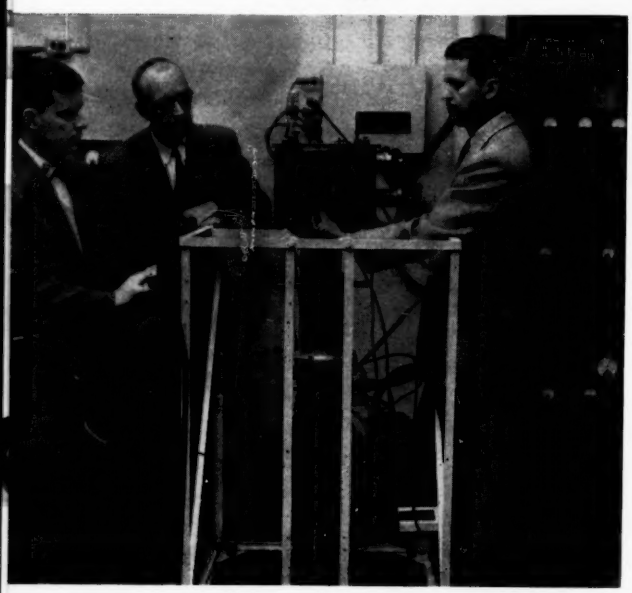
● **REFERENCE DATA:** Write for Specification sheet S1011-3 "New Honeywell Industrial Pressuretrol"

MINNEAPOLIS **Honeywell**
BROWN INSTRUMENTS
First in Controls

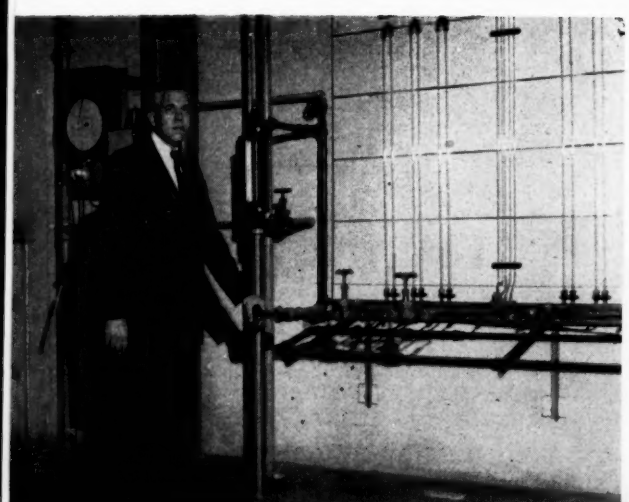
UPDIKE AND GRAY WARD, undergraduate technician, operate the HETAC (Heat Exchange Transient Analog Computer), a passive-network analyzer built at the University of Virginia. A specialized analog computer for solving kinetic equations and a simulator for reaction equipment have also been built for Experiment Station project sponsors. A general-purpose analog computer is now being installed.



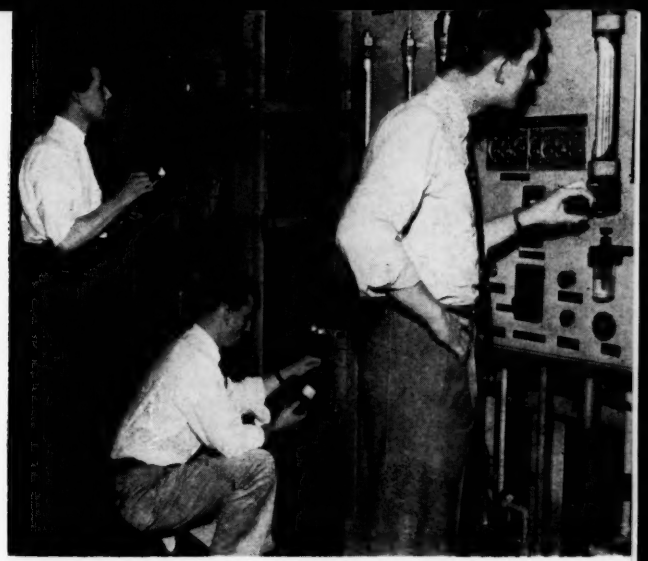
ORVILLE HARRIS, CENTER, DIRECTOR of the University of Virginia Engineering Experiment Station, examines the new molecular beam analyzer for the study of MASER nozzles and focusers, which has an accuracy of one part in a million million. Also pictured are Robert L. Ramey, right, assistant project director, and Kenneth L. Hayes, project engineer. This work is being done for the Army Signal Corps.



University Research

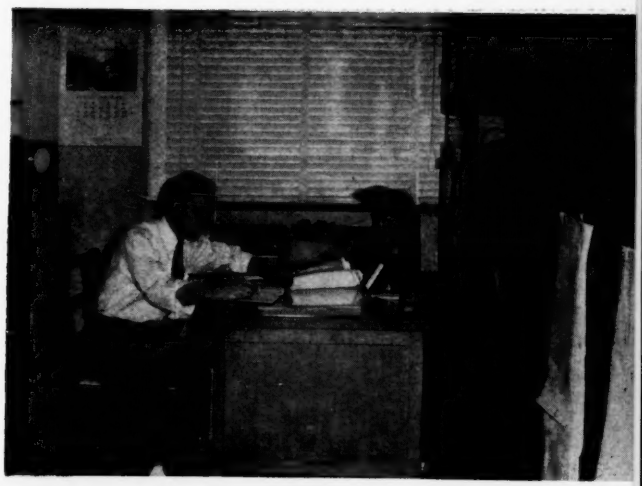


DR. C. E. SCHWARTZ, ASSISTANT PROFESSOR of Chemical Engineering, operates a fluid flow and metering demonstrator which includes a rotameter, an orifice, a Venturi, and a weir box. The pressure drop and friction drop in pipe and fittings are indicated on piezometer tubes and inverted manometers on the board at the rear.



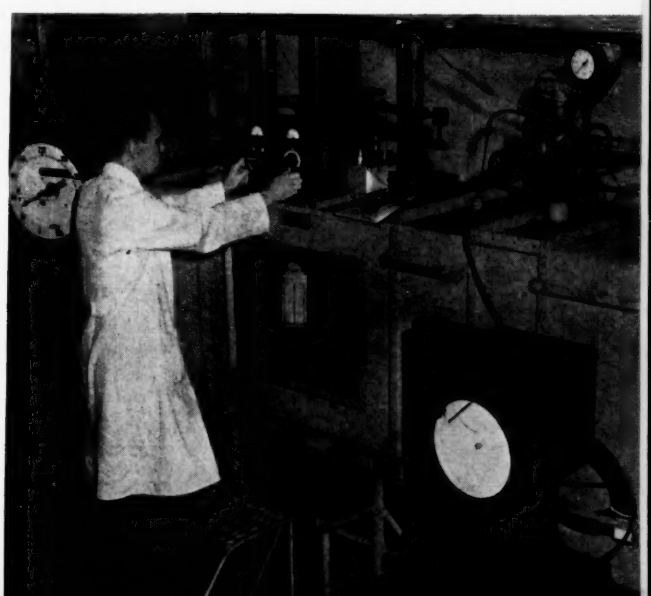
UNDERGRADUATE STUDENTS MONITOR operation of a bubble-cap distillation column in the Unit Operations Laboratory. Equipment in this important instructional laboratory is instrumented to simulate good industrial control practice with flowmeters, temperature recorders, pressure controllers, remote tank level indicators, a continuous hydrometer, and thermometers and sampling points on each plate.

On pages 1071 and 1075 you met Dr. Otis L. Updike of the University of Virginia. Here are some glimpses of the extensive instrumentation included in the research and educational activities of the University.



GRADUATE STUDENT J. A. ROLSTON uses several portable instrument stands in one of the individual graduate laboratories on an Experiment Station project.

Instrumentation



AN EXPERIMENT STATION RESEARCH engineer runs tests with a drying tunnel in a project involving development of a new method of monitoring moisture content of fibrous solids. The recorders used are mounted on portable stands for general laboratory use.

The Instrument Industry

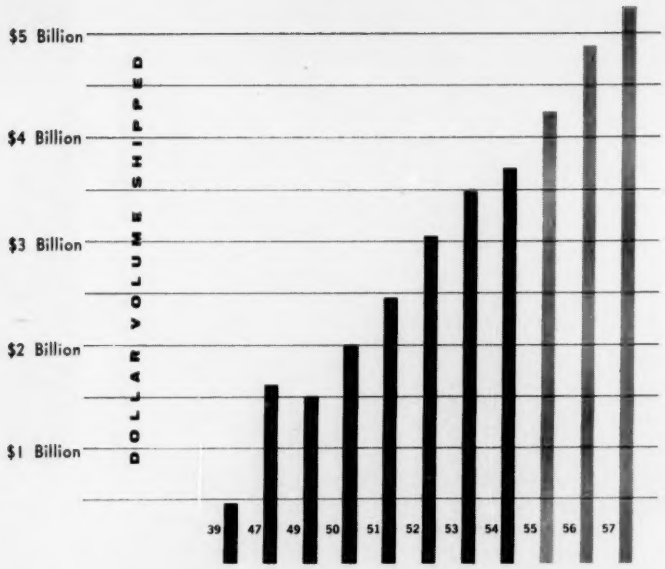


Fig. 1. The instrument industry dollar volume, as defined by the Census of Manufactures. Gray columns are estimates.

An Economic Report by Richard Rimbach

(Publisher)

IN THE January 1954 issue of *Instruments & Automation*, the writer presented a report on "The Instrument Industry—today and tomorrow." This report was the first in the nation to reveal that the Instrument Industry was a multi-billion dollar industry. Recently an unusual number of requests have been received for production information on the instrument industry. It was therefore decided to analyze and report in detail the latest data from the Census of Manufactures, the most authoritative source of economic facts.

The most recent Census of Manufactures was made for the year 1954, but the final report of this Census will not be available until next year. Preliminary reports have been issued by the Department of Commerce and the data for 1954, in the following tables, have been taken from these preliminary reports.

Code Classifications

The Instrument Industry includes the following S. I. C. Code Classifications of the Census of Manufactures:

S. I. C. Code No. 3576—The Scales and Balances Industry represents manufacturing establishments engaged primarily in the manufacture of weighing devices of all types, including those with automatic computing mechanisms and coin-operated scales. Important products of this industry are industrial scales, commercial scales, household and person weighing scales, mailing and parcel post scales, railroad track and motor truck scales, as well as laboratory precision balances.

S. I. C. Code 3586—The Measuring and Dispensing Pumps Industry represents manufacturing establishments engaged primarily in the manufacture of measuring and dispensing pumps including those used in service and filling stations for dispensing gasoline, oil, and grease.

S. I. C. Code 3613—The Electrical Measuring Instruments Industry represents manufacturing establishments engaged primarily in the manufacture of pocket, portable, panelboard, and graphic recording instruments for measuring electricity (such as voltmeters, ammeters, wattmeters, watt-hour meters, demand meters), and other meters and indicating instruments. Also included are companies primarily manufacturing meter transformers and analyzers for testing the electrical characteristics of internal-combustion engines, radio apparatus, etc., and instruments for indicating, measuring and recording electrical quantities and characteristics.

S. I. C. Code 3811—The Scientific Instruments Industry represents manufacturing establishments engaged primarily in the manufacture of laboratory, scientific, and engineering instruments such as nautical, navigational, aeronautical, surveying, drafting, mathematical instruments, and instruments for lab-

Table 1. Annual Dollar Volume of Instruments Shipped As Reported By The Census of Manufactures

Product with Industry Code in Parenthesis	Sales in Thousands of Dollars 1954	1947	1939
Scales & Balances (3576)	59,343	51,489	14,350
Measuring & Dispensing Pumps (3586)	84,901	95,448	44,286
Electrical Measuring Instruments (3613)	345,389	157,453	41,979
Scientific Instruments (3811)	620,427	107,445	42,251
Mechanical Measuring Instruments (3821)	845,342	425,277	89,780
Optical Instruments & Lenses (3831)	121,814	55,134	8,690
Photographic Equipment (3861)	772,531	428,531	133,052
Watches & Clocks (3871)	297,889	332,520	81,475
Totals	3,147,636	1,653,297	455,463

Note: Total for 1954 is increased further by amounts shown in Table 3.

Table 2. Average Number of Production Workers, as Reported by The Census of Manufactures

Product with Industry Code in Parenthesis	1954	1947	1939
Scales & Balances (3576)	4,100	4,900	2,839
Measuring & Dispensing Pumps (3586)	5,900	8,900	5,054
Electrical Measuring Instruments (3613)	21,200	16,100	6,976
Scientific Instruments (3811)	29,700	13,500	6,529
Mechanical Measuring Instruments (3821)	47,700	46,700	15,075
Optical Instruments & Lenses (3831)	9,400	6,700	2,209
Photographic Equipment (3861)	41,200	42,400	16,434
Watches & Clocks (3871)	20,300	30,200	17,335
Totals	182,500	169,400	72,451

Table 3. Annual Dollar Volumes of Instrument Products, Not Included in Table 1, With Seven-Digit Codes, as Reported by The Census of Manufactures

Product Code Classification Number	Product Group	Value of Shipments in Thousands of Dollars 1954	1947
3229065	Scientific and laboratory glassware	23,785	21,273
3229069	Other technical glassware, except electronic tube blanks	932	2,693
3229071	Industrial glassware (including such products as gage glass, instrument faces, machine parts, glass knobs, meter covers, pumps, battery jars, etc.	16,294	12,377
3545200	Precision measuring tools, not specified by type	6,828	2,596
3545211	Comparators	4,517	1,497
3545221	Gage blocks	1,890	697
3545231	Micrometers	3,835	4,249
3545241	Calipers and dividers	1,107	1,270
3545251	Gages	62,180	14,370
3545261	Dial indicators	7,198	2,595
3545298	Other machinist's precision tools	22,478	9,147
3571061	Counters and counting devices	17,981	*
3591131	Automatic diaphragm actuated regulated valves	38,954	24,645
3591133	Float actuated automatic regulating valves	4,166	11,704
3591135	Other automatic regulating valves	38,726	17,312
3591137	Compressed gas cylinder valves	4,432	2,543
3616127	Time switches	7,898	5,765
3616129	Other switches (excluding snap, toggle, push, etc. but including meter service equipment, other than meter mounting and test devices	12,018	7,845
3662111	Electron tubes, cathode ray, TV picture tubes	212,967	7,137
3662211	Other cathode ray tubes (including oscilloscopes, camera pick-up tubes, monoscopes, storage tubes, iconoscopes, and orthicons	16,159	1,057
3693117	Industrial X-ray units	3,285	684
	Totals	507,530	

*Not available. Was reported as part of a larger group

oratory work and scientific research (except microscopes and telescopes which are in Industry 3831—Optical Instruments and Lenses).

S. I. C. Code 3821—The Mechanical Measuring Instruments Industry represents manufacturing establishments engaged primarily in the manufacture of mechanical instruments for indicating, recording, measuring, and controlling temperature, pressure, mechanical motion, rotation, flow, liquid level, humidity, density, acidity, alkalinity, and combustion; dial pressure gages; physical-property testing apparatus such as hardness, tension, compression, torsion, ductility, and elasticity testing apparatus; and instruments for household and office such as thermometers, barometers and rain gages.

S. I. C. Code 3831—The Optical Instruments and Lenses Industry represents manufacturing establishments engaged primarily in grinding optical lenses and prisms and in manufacturing microscopes, telescopes, field and opera glasses, and related optical equipment such as refractometers, spectrometers, spectroscopes, colorimeters, polariscopes, and optical measuring instruments. (Those engaged in manufacturing sighting and fire control instruments but not engaged in manufacturing optical components are in 1941, Sighting and Fire Control Equipment.)

S. I. C. Code 3861—The Photographic Equipment Industry represents manufacturing establishments engaged primarily in the manufacture of photographic apparatus, equipment and supplies. Important products of this industry include apparatus such as still cameras, motion-picture cameras, projection apparatus, photocopy and microfilm machines; equipment such as plate and film holders, tripods, film reels, developing tanks and machines, enlargers, and motion-picture screens; and supplies such as sensitized film paper and plates, and prepared developers, fixers and toners. Parts, attachments, and accessories for photographic apparatus and equipment (except lenses for sale separately) are also included.

S. I. C. Code 3871—The Watches and Clocks Industry represents manufacturing establishments engaged primarily in the manufacture of clocks (including electric), watches, mechanisms for clock-work-operated

Table 4. Annual Dollar Volume of Products of Industries Covered in Table 1, Reported by Seven Digit Codes, (000 Dollars Omitted)

		1954	1947
3576011	Railroad track and motor truck scales	4,878	*
3576021	Bench and portable industrial scales	6,171	5,115
3576023	Built-in industrial scales (including floor and dormant)	2,401	
3576025	Predetermined-weight industrial scales	2,681	
3576027	Automatic weighing and filling scales	6,341	16,771
3576029	Miscellaneous industrial scales (including special purpose, crane, suspension, tank)	5,414	
3576071	Laboratory precision balances	2,659	2,044
3576081	Parts for scales and balances	5,865	2,287
3613111	Single phase A. C. watt-hour meters	36,938	44,967
3613115	Polyphase A. C. watt-hour meters	6,491	5,096
3613121	Combined watt-hour and time switch meters	3,807	*
3613131	Single phase combined watt-hour and demand meters	1,141	
3613135	Polyphase combined watt-hour and demand meters	8,900	6,862
3613141	Demand meters (including KW and KVA)		
3613151	Other electrical integrating meters including D. C., watthour meters, ampere-hour meters, and other miscellaneous integrating instruments not included in above	2,930	2,121
3613160	Parts for integrating meters, electrical type sold separately	12,883	4,604
3613200	Test equipment for testing electrical, radio and communication circuits, and motors	5,679	9,257
3613211	Oscilloscopes, high frequency types, designed primarily for radio testing	7,051	766
3613215	Other types of oscilloscopes and oscillographs	16,475	4,048
3613221	Volt-ohm-milliammeters	4,460	2,535
3613227	Electronic volt-ohm-milliammeters	3,624	723
3613233	Resistor, capacitor, and inductor measuring equipment	3,209	1,653
3613239	Analyzers for testing characteristics of internal combustion engines and auxiliary equipment	23,189	15,193
3613245	Tube characteristic measuring instruments for receiving tubes	5,805	2,058
3613251	Micro-wave test equipment	8,488	2,512
3613257	Signal generators	15,155	3,744
3613263	Broadcast transmitter test equipment	1,622	*
3613269	Radio frequency measuring equipment	13,790	1,813
3613281	Parts for test equipment sold separately	11,389	481
3613298	Other test equipment	68,179	9,992
3613300	Other electrical measuring equipment, not specified by kind	4,422	1,571
3613311	Panel type instruments, normal size 4 1/2" and smaller. Initial accuracy within ± 2% of full scale deflection for all types except rectifier types which shall be within ± 5%. Excluding instruments for use on motor vehicles and aircraft	19,011	8,369
3613313	Panel type instruments, nominal size larger than 4 1/2" including all exploded types. Initial accuracy within ± 2% of full scale deflection for all except rectifier types which shall be within ± 5%.	2,217	2,155
3613315	Panel types for use on aircraft only (for measurement of electrical quantities only including ammeters, voltmeters, volt-ammeters, watt-varmeters, etc.)	2,848	408
3613321	Switchboard type instruments 4 1/2" nominal size and larger with accuracy within ± 1% of full scale	7,157	3,111
3613331	Industrial portable ammeters, voltmeters, watt-varmeters, etc., including hook-on and split core current measuring types	4,223	1,659
3613335	Laboratory portable instruments—with accuracies within ± 1% up to 1/10% of full scale and better, all case sizes	3,461	2,317
3613345	Other indicating instruments, except motor vehicle and test equipment	3,332	*
3613351	Instrument relays—all types	2,098	899
3613361	Recording instruments, not including control types	10,191	1,911
3613371	Parts for indicating and recording instruments	5,985	3,468
3613381	Instrument, meter and tripping transformers (current and potential)	17,649	10,628
3613385	Ammeters and voltmeters for motor vehicles	1,590	2,502
3811111	Aircraft flight instruments and automatic pilots	378,897	20,478
3811198	Other aircraft, nautical, and navigational instruments	136,935	(included in 3811311)
3811211	Surveying and drafting instruments and apparatus	17,998	19,658
3811311	Other scientific instruments and laboratory apparatus (Excluding electrical quantity measuring instruments, and industrial process instruments).	86,594	67,309
3821111	Aircraft engine instruments	80,257	4,992
3821211	Gas meters, integrating, nonelectrical type	37,840	22,459
3821231	Water meters, integrating, nonelectrical type	37,298	23,246
3821298	Other liquid meters (except electric), including gasoline dispensing	31,036	17,557
3821311	Thermometers, industrial and laboratory, glass stem and bi-metal	11,347	12,549
3821313	Thermometers, clinical, glass stem and bi-metal	6,320	5,360
3821315	Thermometers, household	6,808	4,051
3821321	Temperature instruments, other than thermometers	55,268	44,120
3821331	Pressure and vacuum	44,901	27,535
3821341	Fluid flow and liquid level	39,927	19,211
3821351	Physical properties testing and inspection equipment, including hardness, strength of materials, wear, abrasion, and similar testers	19,472	13,402
3821398	Other industrial process instruments	87,475	42,141
3821611	Other and not specified mechanical measuring instruments	51,022	48,519
3821411	Speedometers for motor vehicles	28,774	11,433
3821498	Other motor vehicle indicating instruments, except electric (fuel level, oil pressure, etc.)	47 627	28 062
3821511	Automatic temperature controls, activated by pressure, temperature, level, flow time, or humidity (including pneumatic controls) of the type principally used as components of air-conditioning, refrigeration, and comfort heating	259,970	100,640
3831011	Photographic and projection lenses and prisms, for sale separately	31,178	21,087
3831031	Field glasses, prismatic and non-prismatic; terrestrial and celestial telescopes	9,741	4,293
3831051	Microprojectors, and photomicrographic equipment	977	
3831053	Microscopes	6,854	
3831071	Optical measuring instruments (refractometers, colorimeters, spectrometers, spectographs, spectrophotometers, polariscopes, contour projectors metallographic, etc.)	20,719	29,754
3831098	Other and not specified optical instrument, lenses, parts and accessories	52,345	
3971131	Clocks, complete, including tower, street, master magnet operated secondary clocks, chronometers, etc.	2,841	1,854
3871161	Electrical timing mechanisms, not for timepiece use, including interval timers, driving, recording, time switch, and other devices, but excluding time recording and time stamp machines	24,512	6,791
3871165	Spring wound timing mechanisms, with limitations noted in 3871161	10,012	6,245

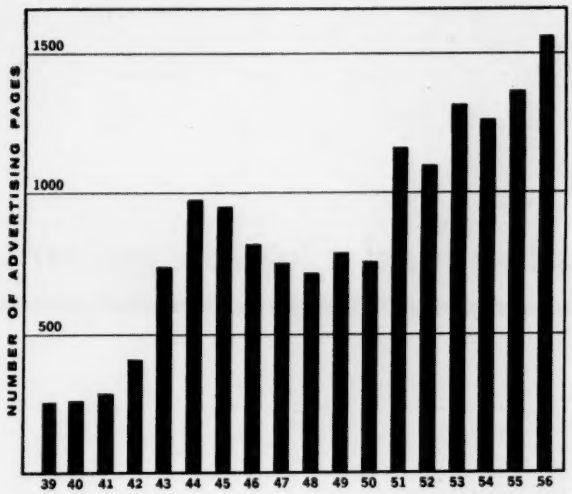


Fig. 2. Number of advertising pages in I&A vs year.

devices, and clock and watch parts. This industry includes establishments primarily engaged in assembling clocks and watches from purchased movements and cases.

Annual Dollar Volume

Table 1 reports the Annual Dollar Volume of Instruments shipped in the years 1939, 1947 and 1954, as reported by the Census of Manufactures.

Actually the annual dollar value of instrument industry shipments is much greater because many products which belong in this field are not reported in the S. I. C. Codes in Table 1, but are included in larger classifications in other industry codes. In the 1954 Census the products were broken into a greater number of products in each industry, so that some of these instrument products can be picked up.

Table 3 shows the annual shipment in dollars of the seven-digit-code products which should be included in Instrument Industry but which are not included in Table 1.

In Table 4 are listed more detailed breakdowns of seven-digit product codes included in the four-digit industry codes reported in Table 1. The following products are not included in the tabulation because they fall in larger classifications and cannot be located in the Advance Reports:

1. Electronic computing and related machines*
2. Electrical control apparatus including electronic inspection and gaging devices and positioning controls
3. Recording chart paper not sold by instrument manufacturers

Fortune reported recently, "Business computers are the industry's hottest new commercial product. Twenty companies are now in the digital computer business, which was zero in 1951. Volume is now about $250 million, and growing enormously."

Table 5. Number of New-Product Items Reported Annually In The New Instruments Section Of *Instruments & Automation*, and Number Of Companies In Field

Year	Products	Companies
1928	84	
1929	106	
1930	133	
1931	233	
1932	283	
1933	308	
1934	311	
1935	306	692
1936	317	
1937	313	
1938	370	
1939	363	854
1940	291	843
1941	246	933
1942	266	964
1943	280	1013
1944	312	1044
1945	393	
1946	647	1264
1947	660	1307
1948	636	
1949	798	1361
1950	1063	
1951	791	1517
1952	1141	
1953	1675	1889
1954	2304	
1955	1900	2569
1956	2068	3371*

* Includes companies formerly in the Instrument Manufacturing Buyers' Guide.

Interest in the instrument industry continues to increase rapidly. Many new companies have been organized and many larger corporations have purchased companies in this field. Since the first economic report in *I&A*, published in 1954, four new publications in this field have been started in the United States. There are now 8 magazines in this field in the United States. The number of publications in the world outside the United States has increased to 24—Australia 1, England 8, France 3, West Germany 4, East Germany 1, Hungary 1, Italy 2, Poland 1, Rumania 1, Russia 1 and Switzerland 1.

The number of companies in this field has also increased as shown in Table 5.

Exhibits and Expositions

Another measure of the increased interest and growth of the instrument industry is the increase in the number of national and international exhibits and expositions devoted to this field. The First Instrument Show in the United States was started by the writer in 1946. The first British Instrument Show was put on in London in 1951. The first Automation Show was arranged by the writer in 1954. The first Instrument Show in West Germany will be held this year.

The Future

A healthy and rapid growth can be predicted for the instrument industry. The industry may exceed an annual dollar volume shipped in 1967 of $15 billion.

JOHN H. McLEOD and ROBERT M. LEGER

Flight Mechanics Section Convair-Astronautics
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Combined Analog and Digital Systems

THERE are several factors which can make it advisable to combine analog and digital techniques and equipment in a single system, or in the simulation of a system.

However, as for all good things you must pay a price!

This discussion considers some of the factors that can make a combined system desirable; some aspects of cost; and some of the ways a combination might be accomplished.

Relative Advantages

Needless to say, both analog and digital equipment have their advantages and limitations, many of which are well recognized. Analog systems are generally considered to be fast and rather inaccurate. They are particularly well adapted to handling differential equations, and are good for systems requiring empirical manipulation.

It is often said that digital computers are slow but capable of an accuracy limited only by the number of digits they are designed to handle. They are well adapted for solving algebraic equations, and for applications where their capabilities can be time-shared between different operations. Their time scale is not fixed, but is a function of the number of computations which must be made, which means that it is not always possible to do a digital simulation in real time.

In passing we would like to comment on two of these popular ideas: Analog computers are *not* inherently fast; in fact they usually have a rather limited band-width. The over-all speed of the analog computer results from the fact that the components operate in parallel. Digital computers with an equivalent number of specialized arithmetic units operating in parallel might be as fast. And digital computers are *not* infinitely accurate. They are precise in that they will present the same discrete answer time after time, but that answer might not be accurate; round-off and truncation effects introduce errors which can be serious if their presence is ignored in the problem setup.

Why Combine Techniques?

Why combine analog and digital components in a single system? Why not decide which is better for your purpose and stick to it? Perhaps you should. Conversion is costly, and the benefits to be derived by combining equipments will have to outweigh this cost. However, there are many factors which might do this.

Most physical systems are inherently analog. Industrial processes, guided missiles, and other systems involving continuous variables are, by definition, analog. Justification for a combined system, therefore, usually amounts to justifying the use of digital subsystems or components in otherwise analog systems. This is not difficult because there are several kinds of operations for which digital techniques and equipment are better suited than analog.

Accuracy has been mentioned, but deserves further consideration. Accuracy is not just something that is nice to have because your ideas of how much error you can stand are fuzzy, so you don't want to take a chance; there are applications where accuracy is an absolute necessity, as for instance those which depend on small differences of large quantities.

Integration with respect to variables other than time, matrix rotation, multiplication and division by variables, and the generation of functions of one or more arbitrary variables are other areas in which digital computers excel. Furthermore, digital computing components are particularly well suited for time-sharing between different operations.

Although most combined analog and digital systems are justified by particular characteristics of digital equipment which make it necessary or desirable to include it in an otherwise analog system, the reverse is sometimes true; some combined systems result from using analog components in otherwise digital systems. Perhaps the reason that this does not happen more often is that there are comparatively few inherently digital systems; business accounting systems and other data-handling systems constitute the greatest exceptions. Analog display systems are sometimes used with

Detailed analysis of the largest combined analog-digital system yet undertaken gives qualitative and quantitative answers to the basic questions of why, when and how such combined systems should be used.

—Why, When, and How

these and thus combined systems result. Digital simulation with analog display would be another example of this kind of combined system.

Simulation of a Weapon System

In the area of simulation there are other reasons for considering a combined system. If a complex system is to be simulated, there will probably be some operations which can best be handled by analog and others by digital components. Convair found this to be the case when they began the detailed simulation of an entire weapon system.

Some facts were rather obvious from the start: It was imperative that the simulation be done in real time to allow inclusion of weapon system hardware, and to conserve operating time. This ruled out an all-digital simulation because the large number of individual computations could not be made fast enough, and because analog equipment would be necessary to connect to some of the weapon system components which were to be included. An all-analog simulation was ruled out by accuracy requirements, particularly with respect to the navigational problem.

Clearly a combined simulation was necessary to fulfill the requirements, but as no such large-scale combined simulation had ever been attempted, there were many questions to be answered. Chief among these were which parts of the simulation should be analog and which digital, and what performance specifications would be necessary for the analog-to-digital and digital-to-analog conversion equipment? To answer this would require detailed consideration of the effect of inaccuracies which would be introduced by the analog equipment, and of the amount of computation the digital computer would be able to handle within the time limitations imposed by real-time simulation. Also requiring special consideration were the effects which would be introduced by sampling the analog data to be digitized. Sampled data systems have certain peculiarities which must be taken into account: Delays are introduced that must be either tolerated or compensated by prediction techniques which require additional computer time or equipment.

To determine the effect of these and other factors a study was instigated at Convair in the summer of 1954 to determine the optimum functional distribution of analog and digital equipment, and to establish the performance specifications for the conversion equipment. Dr. Robert M. Leger, who was later joined by Jerome L. Greenstein, made the study under the direction of Dr. W. H. Schwidetzky, and some very interesting and significant conclusions were reached.[2, 3]

The basic concept underlying the study was that insofar as practical, *analog subsystems and components of the weapon system would be simulated by analog equipment, and digital by digital.* If this could be done throughout, conversions would have to be made in the simulation only when they were made in the physical system; and it would seem that the analog, digital, and conversion equipment used in the simulation would have to be little or no better than that designed for the weapon system. Analog errors would be introduced only in the simulation or parts of the system subject to similar analog inaccuracies. The digital computer would have to do no more computations than the digital system components, and sampling and conversion effects would influence both systems in the same way.

Unfortunately, exceptions had to be made. As the simulation was intended for test purposes, it, like other test equipment, would have to be substantially more accurate than the system under test. As an example, the range of the missile would be an analog quantity generated by an analog subsystem, the missile. The missile travels through space according to the equations of motion, all variables of which are analog quantities. But in the simulation it would be necessary to know the range more accurately than analog equipment would be able to generate it. Therefore, it was necessary to compute it digitally.

Another type of exception may arise where certain operations can be performed more efficiently by digital techniques. For instance, if a missile is rolled and

Table 1—ADDAVERTER (Analog-Digital, Digital-Analog Converter) Specifications

1. Static error	± 0.1% of actual voltage or ± 1 millivolt (whichever is larger)
2. Dynamic error	± 0.1 millisec timing uncertainty; 0.5 millisec time constant
3. Conversion time	A-D 10 millisec max; D-A 4 millisec max.
4. Repetition rate for any one channel	A-D 1 to 20 per sec; D-A 1 to 100 per sec.
5. Time for presentation to and assimilation from the digital computer	24 microsec/word max.
6. Analog sampling	by command of digital computer or external timer, individually or simultaneously with a simultaneity of 0.1 millisec
7. Analog interpolation	hold last analog value until presentation of new value
8. Digital logic	to operate with specified digital computer
9. Analog voltage range	± 100 volts
10. Digital word structure	binary, 18 bit, complement negative
11. Number of channels	A-D 15; D-A 10

receives a pitch or yaw command, the missile solves the equations of motion, with all of the cross-coupling terms, very nicely because of its built-in characteristics. But the analog-computer set-up required to do this is complex and a source of accuracy and reliability problems. It may thus be advisable to transfer some of the more awkward of these calculations to the digital computer—if this can be done within the other constraints of the problem such as digital computing time, frequency response, and inclusion of hardware. It is also conceivable that there might be exceptions in the opposite direction—i.e., some analog equipment might be used to simulate digital system operations.

Usually, if a digital computer is to simulate a continuous feedback system, an output value must be assumed, then combined with the input to get an error term, and a new output computed that is nearer to the correct one than the first assumption. Thus the digital computer approaches the correct value by iterating until the loop calculation becomes internally consistent to within some predetermined amount. At Convair, extrapolation techniques are often used to make the first approximation accurate enough to require little or no iteration.

As a result of the foregoing and other considerations, a combined simulation was designed in sufficient detail to allow formulation of performance specifications for the conversion equipment. Some of these figures, and the criteria from which they were derived, are interesting (see Table 1).

Permissible Static Error

The permissible static error was first determined by dividing the maximum value of the most critical quantity to be converted by the error which could be tolerated at the most critical time in the simulation. The result was approximately one millivolt out of 100 volts, or one part in 100,000! Further investigation revealed that the problem was essentially one of controlling the 100-volt signal toward zero by a closed-loop process with the accuracy of one millivolt at the final zero. Thus errors considerably larger than one millivolt could be tolerated when the signal was large, provided these errors decreased sufficiently as the signal level decreased.

Permissible Dynamic Error

When the parameters being converted are changing with time, dynamic errors are introduced by timing inaccuracies and smoothing filters. Ideally, if a maximum rate of change of signal is assumed, specifications for these factors could be computed such that their contribution to the over-all system error would be of the same order of magnitude as that caused by the permissible static error. In this case a static error of 1 millivolt and signal rate-of-change of 10 v/sec would dictate a maximum timing uncertainty, δt, of 0.1 millisecond in the sampling and presenting operations. Signal rates greater than 10 v/sec may be encountered occasionally, but the specification for a δt max of 0.1 millisecond was retained because it was not desired to rule out the possible use of relays. Although relays could not be expected to operate in 0.1 millisec they could have a time of operation (time from the command to the actual sampling or presentation) which is predictable to within 0.1 millisecond.

The dynamic error introduced by smoothing networks may be specificed in terms of that error which would be introduced by a low-pass filter of time constant τ. As the effect of τ is essentially the same as that of δt it should be of the same order of magnitude—i.e., 0.1 millisecond. However, again practical factors such as the noise versus band-pass considerations of the analog equipment, and a desire not to make the specifications too difficult, prevailed.

Conversion Time

If the complete cycle from analog to analog is considered (i.e., sample, convert, deliver to digital computer, compute, deliver to converter, hold, convert, and present to analog computer), it will be seen that only delivery to the digital computer, actual computation, and delivery to the converter actually require digital computer time. However, all eight operations add to the total loop delay. Therefore, as the conversion time in any event would be short compared to the computation time, it would seem that it could be specified long enough to leave the conversion equipment designer some choice of techniques. On the other hand, as too long a lag would not be desirable, 10 milliseconds was chosen as a reasonable compromise.

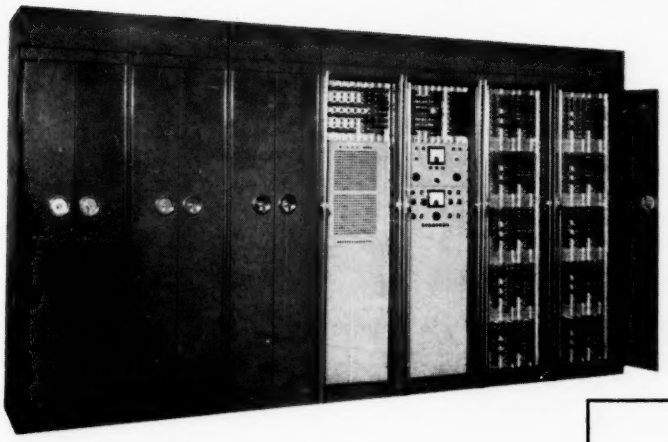

FIG. 1. THE ADDAVERTER, which permits high-speed combined analog and digital simulation. (Photo courtesy Epsco, Inc.)

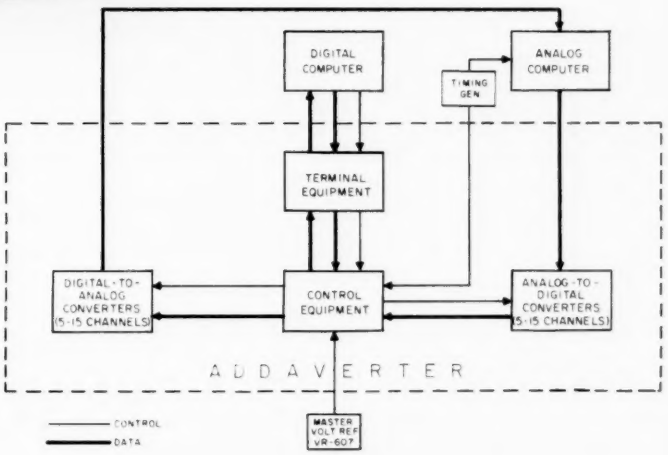

FIG. 2. BLOCK DIAGRAM of a combined analog-digital computation system.

Repetition Rate

The specification for repetition rates (A-D, 1 to 20 per sec; D-A, 1 to 100 per sec) resulted from a consideration of the computation time of the digital computer and the frequency and accuracy requirements of the problem.

Computer-Converter Input Time

If full advantage is to be taken of the computer speed, the conversion equipment should be capable of delivering data to, or accepting data from the computer at the maximum rate at which the computer can handle it, which was 24 microseconds per word, max.

Analog Sampling Rate

In the particular simulation under consideration we will simulate in real time. The simultaneity* specification (0.1 millisec) arises from a consideration of the permissible dynamic error. This is particularly important in cases such as the sampling of the three components of a rotating space vector.

Interpolation

Step interpolation (holding the last analog value until a new one is presented) is the simplest form, and the study indicated that it would be adequate for most of the channels in our problem. It can also be used as the basis for more sophisticated schemes.

* Simultaneity refers to the time of sampling digital data and presenting analog data on parallel channels.

Digital Logic

The logic of the conversion equipment must be such that it can accept and interpret signals from the digital computer and supply acceptable signals in return. It must take into account the fact that the analog computer operates on a rigidly fixed time-scale whereas the digital computer proceeds at a rate dependent on the complexity of the computation without regard to the time scale of the analog computer or the system being simulated. Therefore, the logic must also prevent the digital computer from proceeding with a new calculation before the new input data have arrived.

Analog Voltage Range

The analog voltage range of the converter should be the same as the full-scale range of the analog computer ($\pm$ 100 volts), otherwise either the converter or the computer range could not be used to full advantage. The impedances must also be compatible.

Digital Word Structure

The treatment of negative numbers in the digital word structure is determined by the machine language of the digital computer, and the length of the word by the dynamic range required. An 18-bit binary code is suitable, with a negative complement.

Number of Channels

The number of channels in each direction is determined by the system and the method of simulating,

plus any special considerations such as analog display of digital quantities and digital monitoring and correction of analog operations. Fifteen A-D channels were needed; ten D-A channels.

Cost

What about the cost of such a simulation? The one which Convair is undertaking will involve about $2,300,000 worth of digital, $1,600,000 of analog, and $200,000 of conversion equipment. If this total equipment cost, plus many manhours planning and execution, were all chargeable to this one simulation the cost would indeed seem high. But this is general-purpose computing equipment which has been and will be used for many other purposes, so the exact cost of the simulation will be a function of the bookkeeping.

Perhaps it is more pertinent to ask the cost of not simulating. This means additional missiles and additional test flights. Do you know the cost of a test flight plus the cost of the missile that is expended? Again the exact amount is a matter of bookkeeping, but one thing is certain: by any system of reckoning it can be shown that the cost of just one test flight of any particular missile is substantially more than the prorated cost of the equipment, manhours, and headaches that would be required to simulate it. And remember, the equipment can be used for additional simulations, general computing, and many other purposes for years to come whereas a missile, once flight tested, is gone forever. Does simulation still seem expensive?

Planning a System

Let us consider a more general case. Suppose, after due consideration, it is believed that a combined analog and digital system can solve a particular problem. And suppose that the analog and digital components are available. How are they put together? What parts of the system should be analog and what parts should be digital? And how is the information converted from one form to the other?

In general, *analog components* should be given first consideration for parts of the system involving:

a. High-frequency integrations, summations, and multiplication and division by constants

b. Empirical manipulation (knob twiddling)

c. Analog inputs and/or outputs

d. Analog system components

e. Over-all accuracy no greater than 0.1 to 1%

f. Feedback loops

For simulation, analog components should also receive first consideration for the simulation of those parts of the physical system which are analog.

Digital components should be given first consideration for those parts of the system involving:

a. Great precision

b. Operations which can be time-shared

c. Small differences of large quantities, matrix operations, multiplication and division by variables, and generation of functions of arbitrary variables.

d. Rapid change of problems and problem storage between successive operations

e. Digital inputs and/or outputs

f. Digital system components

Digital components should also receive first consideration for the simulation of those parts of a simulated system which are digital.

In concluding we realize that no specific answer has been given to the question of when analog and digital components should be combined in a single system. That is because there is no pat answer—each case must be studied individually. We can, however, remind you of points which should be considered.—What is the input? The output? Are physical components to be included? Are they analog or digital? If there is related equipment, or if you are considering simulation of a physical system, is it analog or digital? Factors related to the environment of the system also should be remembered.

Consider equipment and personnel availability. What kind of equipment do you have? What kind must you get? Can you get it? When? What equipment has your personnel had experience with? (Prejudices run high in the computer field!) The answers to the foregoing might outweigh all other considerations.

What will be the *net* cost of such a system? Of course some circumstances can make a combined system mandatory, but if you have any choice, weigh the advantages which you may expect from a combination against the disadvantages. The combined system may be more accurate than an all-analog one and/or faster than an all-digital. If a mixed physical system is to be simulated the combination may result in a more realistic simulation. On the other hand there might be deterioration of information caused by analog inaccuracies and/or digital sampling; lessened stability due to lags introduced by conversion and digital computation; or reduced reliability resulting from increased complexity.

Finally, what is all this going to cost in dollars? Can you raise it?

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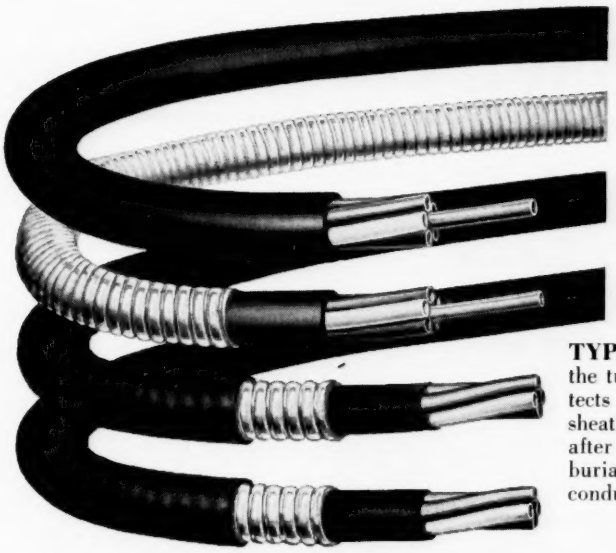

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Orifice-Meter Maintenance

First step in maintenance is logical analysis of the problem. Next comes a routine number of check steps that cover instrument zero, mercury level, leaks, calibration, and controller action.

DALE D. KOEPKE

Union Oil Company of California

ORIFICE-METER maintenance is a daily problem for all of us involved in industrial process control. Rather than discussing individual mechanical adjustments on any particular type of instrument, this discussion will be held to general checking procedures and problem analysis. Although there are three basic types of orifice meters—the mercury manometer, the bellows type, and the diaphragm type (Fig. 1)—this discussion is based on the mercury-manometer type of flowmeter.

Problem Analysis

The most important phase of orifice-meter maintenance, regardless of instrument type, is *logical analysis of the problem*. In order to logically analyse a problem in instrumentation, it is necessary to connect theoretical knowledge to practical application. If necessary, draw a sketch of the control system and be sure the complete problem is understood before making adjustments. By systematic analysis of the problem, it is often possible to save a great deal of time, effort, and expense.

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One of the most frequent jobs is checking a meter for *accuracy*, which is often called *rate check*. Too often the technician, pushed by a heavy work load, checks only the pen travel to zero when the meter bypass is open (Fig. 2). This type of check tells little about the operating accuracy of the instrument.

Assuming that the meter is controlling a flow of gas, the proper first step in checking the installation is to determine what other instruments or equipments are affected by this controller, and then have the operator put the system on manual control. In taking this first step of *problem analysis* it is necessary for the technician to familiarize himself with the process and the control problem at hand. This first step may be accomplished in a few minutes or it may require hours. Nevertheless, *it is of utmost importance.*

General Checking Procedure

Assuming that the instrument man has a thorough understanding of the control problem, the process involved, and working knowledge of the instruments, the next step is to perform the checks listed in Table 1.

Table 1.—Gas Flowmeter Check Procedure

1. Zero
2. Mercury Level
3. Leaks
4. Proper Calibration
5. Controller Action

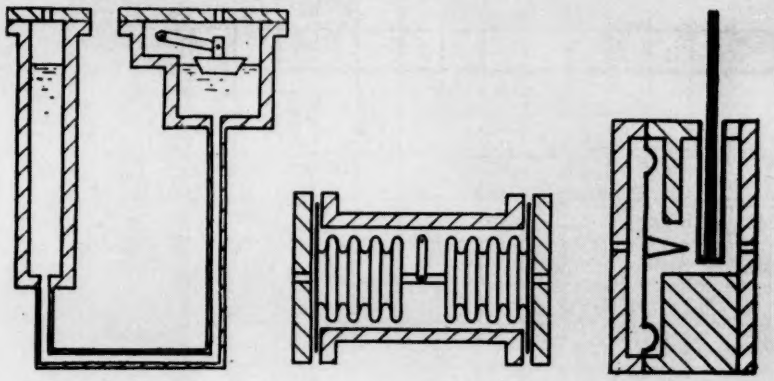


FIG. 1. BASIC TYPES of orifice meters include (left to right) the mercury manometer, bellows type, and diaphragm type.

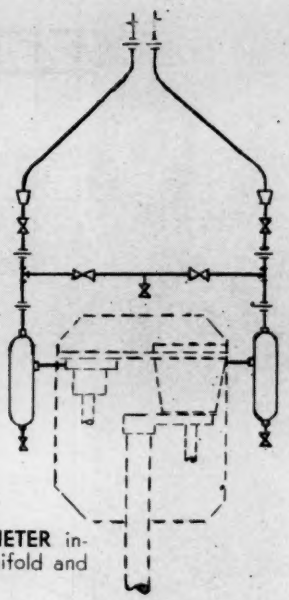


FIG. 2. TYPICAL ORIFICE-METER installation, showing bypass manifold and seal pots.

Zero Check

First, check for zero. The meter being discussed is a gas flowmeter, but no matter what type of flow is being measured—whether liquid or gas—there is only one proper place to block the meter for a check of zero flow condition. *This is at the orifice.*

If this is a sealed meter the bypass *at the seal pots* must be opened to check for zero. If the bypass at the instrument is opened instead, it is possible that the columns of sealing liquid from the sealing pots will be of unequal heights, giving a false zero, even if the meter is properly sealed. A meter properly bypassed at the seal pots will indicate immediately whether or not an unequal seal level exists. If for any reason doubt should arise as to the proper amount of sealing liquid in the pots, the meter should be resealed —that is, the bypass on the pots closed, the pots vented to atmosphere, and sealing fluid added. This method facilitates a positive and equal seal in both legs of the meter piping.

Mercury Level

Number two on check list is *mercury level.* This is checked by allowing the meter to equalize to an extreme scale position; then be sure there is a small amount of float travel remaining. In other words, be sure the float is not against a mechanical stop when the meter is in the extreme scale position. The extreme scale position, for the gas flowmeter under discussion, when equalized, is the zero point on the scale; other meter applications may have various scale readings when the meter is in an equalized condition.

Leaks

The third point to check is for *leaks,* either in the meter piping or in the meter itself. First, be sure the valves in the meter piping do not leak when closed off. Then, by applying a differential pressure to the meter, drive it to approximately half scale. At this point block off the applied pressure and seal it in the meter. If the meter does not move it can be assumed that the meter and piping up to the blocked valves is gas tight. Next, block the meter at the orifice and check for meter movement. This method of checking for leaks makes leak location a simple matter.

Calibration

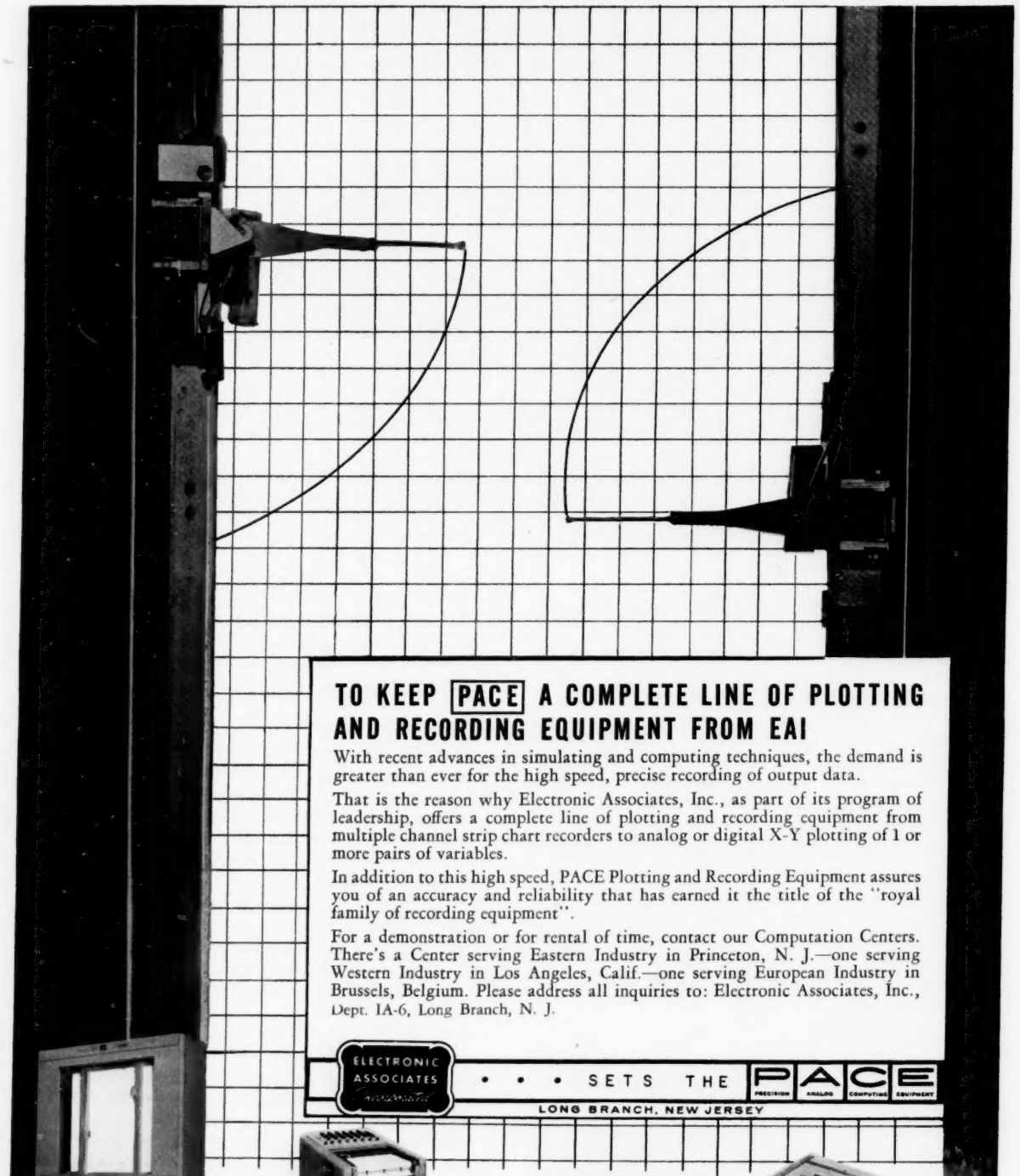
Point number four on the check list is *proper calibration.* This step must be done with an accurate measuring device to measure applied differential. This is true regardless of the type instrument used, whether mercury, bellows, or diaphragm type. One of the most foolproof check instruments to use for this purpose is the manometer. The instrument man should have a thorough understanding of the instrument being calibrated. Valuable helps for the technician may be found in the manufacturer's instruction manuals, which should be available for easy access.

Controller Action

Point number five on the check list is to check the controller action in the process. Be sure that controller action is correct for the type valve (air-to-close or air-to-open) being used, and also be sure the control valve itself is operating properly.

One step that was intentionally omitted from the check list was checking a pressure pen for calibration. It was assumed that the meter in this discussion was operating under constant line pressure, making a pressure pen unnecessary. If a pressure pen is required because of varying line pressure, the checking procedure should include a test to assure that the pressure pen is reading correctly in psia.

A final word on personnel. Successful instrument work requires skilled technicians. These are men who have a basic knowledge of physics, math, mechanics, and some chemistry—and, of utmost importance—initiative and the desire to learn.



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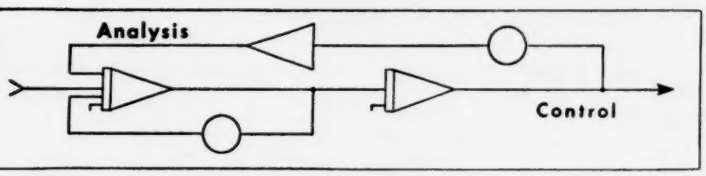

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R. R. Favreau, Princeton Computation Center, Electronic Associates Inc., Box 582, Princeton, N. J.; Chairman, Steering Committee.

Canadian Simulation Council

F. W. Pruden, Analog Computation and Simulation Group, Mechanical Engineering Div., National Research Council, Ottawa, Canada; Chairman, Steering Committee

Bits

This month, Pieces is concerned with a discussion by *Dov Abramis* (Convair-Pomona, Calif.) on "Evaluation of Computer Performance," followed by *Bernie Loveman* (Reeves Instrument Corp., New York, N.Y.) unburdening himself of some personal observation on misinterpretations in general and some by this *Newsletter* in particular.

Dov's talk will be of interest and importance to everyone concerned with management of a computing facility. He discusses ways, means, and criteria by which those operating a computing facility can answer to their own and management's satisfaction that all-important (but hard-to-answer) question—"How're we doing?"

Bernie's remarks are of more general interest, and are very pertinent, but we have had to sacrifice a good bit of the detail (and practically all the color) because Bernie does not wish to be quoted unless he can review the write-up before publication. This has the double disadvantage of delaying publication and inhibiting ye Ed (a serious thing indeed!) so it seems best just to give no direct quotations.*

Regardless of Bernie's feeling about this *Newsletter's* quoting, or misquoting, one thing is certain; he has a point—or group of points—which should not be overlooked by anyone contemplating the purchase of equipment.

* Bernie hurriedly okayed this write up just before dashing off to get married. Congratulations, Bernie.

Pieces

WESTERN S/C MEETING OF 14 MARCH ON "EVALUATION OF COMPUTER PERFORMANCE"

Being important has its disadvantages. *Jack Sherman* is Chairman of the Steering Committee of the Western Simulation Council. He arranged the meeting which was held at Lockheed Missile Systems Division in Palo Alto, Calif., on March 14th. But Jack is also important to Lockheed MSD, so important, in fact, that he was not even able to attend his own meeting, so *Norm Irvine* (Mid-Century Instrumatic Corp., Los Angeles, Calif.), Chairman Emeritus, conducted the meeting in his place.

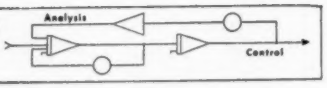
Abramis on Computer Performance Evaluation

Norm introduced *Dov Abramis* (Convair-Pomona, Calif.) who described a method for "Evaluation of Computer Performance."* Dov said he had just found out that the title meant one thing to him and quite another to Bernie Loveman (Reeves Instrument Corp., New York, N.Y.), who would give his ideas on the subject later in the meeting.**

By evaluation of computer performance Dov means some method, primitive as it may be, of gaging how well you are doing. Computers

* Your Editor distilled this write up from 61 typed pages of notes, which quote Dov as saying that he and Jack Sherman dreamed up the title of Dov's talk at the Western Beer Conference. I mention this only to indicate the kind of notes I have to work from. Certainly the Western *Computer* Conference was intended—or was it??

** Thus demonstrating that semantics, which can foul up international relations (cf. the song about Jenny who "in 27 languages couldn't say no"), also can foul up engineers and scientists, especially those in a new field.



are expensive gadgets and once you have one, you certainly owe it to yourself and to management to show that you are doing something useful. One way to judge computer performance (in the case of the analog type, at any rate) is by the amount of paper used. If you use miles and miles of record paper, you know that the computer is putting out something. But all that this really indicates is that you are contributing to the stockholders of Brush, Sanborn, etc.

We would like to see how well we are doing today compared with yesterday, how well our division of the company is doing and, in the final analysis, how well our computer installation is doing compared with others. The purpose is not to establish champions, but to enable us to learn from each other, and to establish a quantitative, rather than qualitative, measure of over-all performance.

Convair-Pomona's system is colored by its particular computer installation. They have been producing marks on paper for about four-and-a-half years. They also keep maintenance records that tell what part was fixed and when, which tube was replaced, and so on. Stan Rogers and his group at the San Diego Division have done quite a bit of work with reliability and the prediction of reliability in computers.

Dov's main concern is to determine how much of the time the computer is actually available and how the operator regards the computer (as a *tool to produce data*, or as a *tool to produce useful results*). Dov distinguishes between the two factors because after the data leaves the computer the man might change his mind and throw the whole lot in the waste basket. They have no control over this and it does not appear in their statistics. However, it would be nice if someone devised a system that took such actions into account!

In Pomona they have analog and digital computers operating side by side, and they have tried to establish criteria which are fairly similar. Dov discussed only the analog aspects of his operation.

The Pomona installation includes eight main control stations plus a half dozen small ones. Dov's group has responsibility for the entire equipment area and for seeing that the equipment (used mostly open-shop) is in working order and capable of solving the operators' problems. Sometimes there are differences of opinion in an open-shop operation as to what is useful and what isn't, so they try to keep records, made both by the operators and by the electronics people.

Operation and Service Records

The following is the information which they expect from their people. This is in addition to a straight maintenance log which discusses failures, etc.

Operator Entries	*Service Entries*
1. Computing Runs	1a. Restoration of Service
2. Analysis	2a. Problem Modification
3. Repatching	3a. Test 3-1a. Computer Modification
4. Calibration	4a. Idle
5. Check Runs	5a. Utilization
6. Operation Errors	6a. Check-out
7. Equipment Fault	
8. Unexplained Troubles	
9. Grand Total (Discrepancies)	

If the operator is mad at us, it will reflect in his entries—they like to have them colored in that way.

(1) *Computing Runs* means paper coming out which is useful to the operator at the time, though he may subsequently discard it. (2) *Analysis* is the head-scratching period between paper runs, when the operator decides what to do next. If he does his thinking with his patchboard off, thus allowing somebody else to use the computer, we are not interested. This entry is made only if he is tying up the computer. (3) *Repatching* requires no explanation. (4) *Calibration* covers setting pots, function generators, etc. (5) *Check Runs* are runs that the operator makes to satisfy himself that he is getting the same results today that he was yesterday. (6) *Operation Error* is a mistake, admitted by the operator, that causes lost time. (7) *Equipment Fault* covers only computer time lost due to an equipment fault, not the time required to fix the fault. (8) *Unexplained Trouble* is exactly that. Something is wrong, but they don't know what.

Dov's people don't try to measure these things to the minute. Operators are supposed to make an objective evaluation to the nearest half-hour or so, and it is hoped that the cumulative effect over a long period of time will provide an index.

They also have a digital computer, so they give it work it can specialize in. The digital computer does statistical evaluation on the analog computer as well as on itself. As operators don't look at their watches, the time increments don't necessarily add up to 24 hours a day; the computer takes this into account.

Besides keeping a separate log to report faults, the electronics people make the *Service Entries* listed: (1a) *Restoration of Service* is the time required to restore a particular patchbay service. This time will be very much smaller than *Equipment Fault* time as entered by the operator, as the latter includes time lost by the operator in trying to get sense from a faulty computer. (2a) *Problem Modification* means time lost moving people from one bay to another because of the shift situation or other logistics operations. (3a) *Test* covers time spent in checking the computer for correct operation. (3-1a) *Computer Modification* is self-explanatory. This is a continuous process. (4a) *Idle* time means just that and is significant because of prorating the cost of computer operation. The more idle bays, the more it costs the customers who use the other bays, because staff and other costs remain the same. (5a) *Utilization* is a figure arrived at by taking TTOC (*T*otal *T*ime *O*n the *C*omputer), 24 hours a day, minus checkout and lunch time, and subtracting from it the total of the preceding items 1a through 4a.

These entries are made on a log (Dov passed out samples), which is converted to punched tape suitable for the digital computer.

Cost Weighting Factors

Because they have eight main bays, plus a number of smaller ones, they are interested in bay hours. It is not fair to rate a small computer the same as a large one, so there are various weighting factors. At the end of every week, and at the end of the accounting month, they get a run from the digital computer. The monthly report goes to accounting for the proration of costs. The computer is financed by charging accord-

ing to the bay hours used by individual customers. If a customer takes two bays, he is charged twice as much as if he took one bay. Because the cost per bay hour is a variable factor, customers occasionally become unhappy. But some of them, for the first time in four-and-one-half years, have come to the point of thinking that maybe instead of spreading themselves over three bays, they should make their simulation a little sharper and put it on two bays. From Dov's point of view this is fine, because it allows more effective use of the computers.

Some of the factors they try to measure are:

A. Effective Utilization
B. Reliability—(TTOC—1a)/TTOC
C. Checkout; 6a/(TTOC + 6a)
D. Virtual Availability
E. Idle; Idle/TTOC

A. **Effective Utilization** is the sum of 1 through 5, divided by 9. Notice that this is taken completely from the operator's log. He is the one who tells how effectively he used the computer.

B. **Reliability** is supposedly an index of how electronically reliable the equipment is. Unfortunately, it is a very poor index, partly because of the way it is kept, and partly because restoration of service is the only item considered. Bench time and Saturday and Sunday maintenance are not included. According to the curves, reliability may be running close to 100%, but that doesn't mean that there is no computer trouble.

C. **Checkout** time is obvious; it is the portion of time the computer is not available while being checked out.

D. **Virtual Availability** is determined by adding items 1 through 6 (6, *Operation Errors*, is included because during the time the operator was making the error the equipment was available to him) and dividing that by the total plus checkout time. If, over a long period of time, the effective utilization is running low while virtual availability is running high, something is wrong with the operator!

E. **Idle** is simply unused time with respect to total available time.

Examining the records, which were started in November, '56, one can see that the Reliability factor runs close to 100%. However, Effective Utilization, which is presumably what the operators are concerned with, runs (at times) as low as 75%. "Look at it around Christmas time," Dov said. "There seems to be a significant change in the pattern. I haven't been able to find out exactly what was happening then, but it can be assumed that our system is an index to something!"

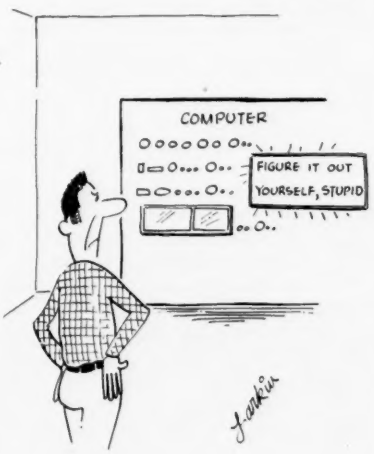
Discussion

Concluding his talk, Dov asked for comments. *Norm Irvine* said he noticed that Dov had some measure of operator proficiency, and asked whether it would not be possible to gather similar valuable information on how well the computer people are doing. "How long on an average does it take to find equipment faults?"

Dov said this could be determined to some extent from the entries under "Restoration of Service" and went on to explain that the record "Operation Errors" was not kept to tie the monkey on the operator, but to gather constructive information. "Suppose, for example, the log shows that in setting pots there is a lot of operational error. Obviously the pot-setting system is no good."

Hank Flum (Reeves Instrument Corp., Los Angeles, Calif.) wondered if Dov had considered the amount of time necessary for patching the problem, setting scale factors, etc.

Dov replied that original patching cannot be included because normally it is done away from the computer, but that "Calibration" and "Check Runs", the sum of 4 and 5, can be an index. The intent of dividing the entries that way was to get exactly this information. They were interested in this because when automatic pot setting was first considered there was a big discussion as to whether it really would do anything. They have now taken quite a few spot checks and are convinced that in their case it has paid off.



Bernie Loveman asked whether somebody keeps a record of how many *runs* are actually made? He pointed out that people say "It takes a minute to make a run; a thousand runs should take a thousand minutes." He wondered if anybody has ever divided the total time by the number of runs to see how long a 'one-minute' run really takes?

Dov replied: "This is something that we discussed. The difficulty in trying to determine anything from the number of runs is that they are so much a function of the problem. Besides, it gets into the human relations area. So far we have not been able to get the operators to count the runs they make. We will probably have to get an automatic gadget to do that."

Bernie agreed and asked, "Speaking of human relations, isn't there a natural tendency for Item 6, 'Operation Errors,' to be very low?"

"Amazingly enough, no." Dov replied. "We thought it would be, too. In most cases—at least over a long period of time—we feel that we get a fairly honest evaluation."

Jack Simmons (Goodyear Aircraft Corp., Los Angeles, Calif.) asked, "If a chopper should go out, the technician pulls the whole amplifier out and replaces it. If he spends much time repairing it, is that time considered?"

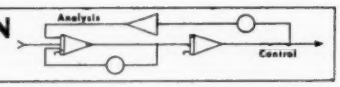
Dov said "We have a spare for everything we can think of. And we never, if we can avoid it, fix anything at the computer. Repairs away from the computer are not considered here. We have cards that tell the history of each piece of gear and on these we keep statistics as to what's done and how long it took."

Cost Vs Utilization

Stan Rogers (Convair-San Diego): "Another aspect of the problem is that with high utilization the average cost per station is relatively low, but when there is lower utilization the customer must pay more."

Bob Turner (Lockheed Missile Systems Div.): "Doesn't this make the customer unhappy? How can he schedule his computer money?"

Dov: "It does occasionally make him unhappy, especially when he gets to the end of his budget and he



doesn't have any hours left. But we are doing the best we can. It is obviously impractical to try to vary the computer staff according to the exact number of bay hours that happen to be used. You cannot train people adequately that way; it only makes a bad situation. We try to base our hiring rate not on maximum utilization, but on some sort of average. We know that it will never be full three shifts, 24 hours a day, seven days a week. Fortunately, we have a number of other jobs, constructing special computers, etc., which means our people do not have to use charge numbers for which the customer pays. On the average, we will run roughly 80% of maximum. The fact that the cost per bay hour will vary is no different from any other computer installation, especially digital ones. We found that out when we went to our sister division in San Diego to get some IBM 704 hours. We had a problem ready to go about a week after the 704 arrived in San Diego. Because we were among the first users and because during that month the use was light, we paid $600 an hour. If we had waited a few months the figure would have been $200 an hour. When you get into this cost business you do have difficulties of that type, but frankly, I don't have a solution."

Stan: "At San Diego we have an accumulative cost-per-year to date. Each month there are adiustments made in previous charges based on the average utilization of the computer for all time on all shifts since the first of January. Anyone who uses the computer throughout the year, therefore, will find his charges based on the average yearly usage, and they will not vary from month to month. But if you should come in December, you would have one rate applying to the period in which you were using the computer. A new year starts in January and a whole new cost accounting period. You might then come out with a different rate. In your case, Dov, you did."

Dov: "How do the manufacturers' computing centers arrive at their fixed rates?"

Joe Hussey (Berkeley Division, Beckman Instruments Inc., Richmond, Calif.): "We are not necessarily a non-profit organization, although our management sometimes insists we are! Therefore the fluctuation is absorbed as more profit or less profit. In terms of dollars per bay hour, what do your prices come out to be?"

Dov: "Well, I think we are charging about a quarter of the rates that I have heard quoted by commercial computing centers, but there is no amortization involved."

Bernie Loveman (Reeves Instrument Corporation) said that at Project Cyclone they operate a large computer installation for the Bureau of Aeronautics. This computer is available for the Government agencies and their contractors (C.P.F.F. only). Charges are based on man power only and there is no charge for the use of the equipment. The current rate is about thirteen dollars per man hour.

Loveman on Reliability of Multiplier Specs and Newsletter Comments

Bernie Loveman volunteered that members of the Eastern Simulation Council are concerned not only with the reliability and usefulness of a system, but of each kind of component in it; in fact they have begun a study along these lines.

Explaining that he is disturbed by what some people have been quoted as saying in the *Simulation Council Newsletter*, Bernie invited rebuttal to the statements he was about to make. He then referred to items in the February 1957 issue of the *Newsletter*, which are repeated here verbatim and in context.

On page 284, as part of a report of discussion following your Editor's reading (at the First International SC meeting in New York City) of a paper entitled "What Next in Analog Computers?" by *Stan Rogers*, there appeared the following:

"*A. J. Zeichner* (Sylvania Electric Co., Waltham, Mass.) wanted to know which multiplier Stan referred to when he wrote: 'The newest electronic multiplying equipment that we have received appears to be clearly superior in accuracy and stability to some of our older equipment.'

"McLeod 'lowed as how it must be EA 'cause 'There are more EA people here than other vendors!'"

Then on page 287 of the same issue, in a report on a talk by Bob Johnson (Georgia Tech) "Basic Error Considerations in Analog Computers" given at a Southeastern Simulation Council meeting, the following appeared: "The electronic multiplier is capable of relatively high-frequency operation while maintaining reasonable accuracy. The time-division type can easily achieve 0.1% accuracy with a frequency response flat to 200 cps."

Now whether or not Bernie was afraid of a transference of thought in prospective customers' minds (which would make them think we said EAI computers can achieve 0.1% accuracy at 200 cps) is unimportant. What is important—to all of us—is the fact that such remarks made Bernie sufficiently unhappy to cause him to fly out to the March meeting of the Western Simulation Council to tell them in no uncertain terms how subject to misinterpretation, if not actually misleading, some statements can be concerning the performance of equipment.

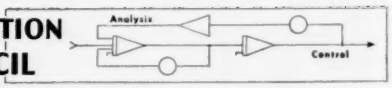
Although Bernie used statements about time-division multipliers as his primary target, he also attacked misconceptions about resolvers and sundry other things, such as dividing an error by 100 or 200 to get "percent" error (instead of dividing by the actual amplitude that gave rise to that particular error or giving voltage data instead of percentages).

Concerning time-division multipliers, Bernie said he had heard claims that some have static errors of as little as 0.01 or 0.02% and dynamic response to 1 or 2% at 100 cycles. Then, as an afterthought, it *may* be stated that at 100 cycles there is an 8-degree phase shift. But an 8-degree phase shift amounts to an instantaneous error of 14%. The phase shift and resultant error are largely due to the output filter, but it matters little *where* the error is.

Suppose you do not intend to use your multiplier at 100 cycles; suppose 10 cycles is the higest frequency of concern. The phase shift is approximately proportional to frequency, so at 10 cycles the error may be as little as 1.4%. So you go to one cycle and still have 0.14% error. What happened to your 0.02% multiplier?

At the present state of the art, Bernie believes that dynamically the accuracy of time-division multipliers is not even one order of magnitude better than the accuracy of a high-quality servo. The only solution, he says, is to push the usual 5- to 10-kilocycle internal reprate by one or two orders of magnitude—and that will take some pushing. However, if it can be done, then we will really have something.

But there will still be noise. Noise will amount to from 100 to 500 millivolts. What is that going to do to your 0.02% multiplier?



What Bernie is really interested in, he explained, is a meaningful way to measure performance. The error, not amplitude or phase shift, but the mathematically correct answer minus the actual output is what really counts!

Bernie also would like to educate the customer so he will know what information to ask for. The better the information the vendor supplies, the better the user will be able to evaluate his equipment.

There was general agreement that Bernie had made some good points and that in so doing he performed a service for the conscientious vendor as well as the customer. However, there were also some illuminating remarks made by others.

Dov Abramis recalled that at a Simulation Council meeting held at least three-and-a-half years ago, *Lee Cahn* (then at Beckman, now of Cahn Instruments) and "others of us did exactly the same thing as you are doing right now and tried to find out what is important about a multiplier. Lee suggested a chart with x's and y's varying all over the place to show the error with respect to various inputs." Dov went on to say that most of us are really not so dumb; we are all aware of the fact that when we speak of a 0.01% device this is not the whole story. At Pomona they have a Reeves time-division multiplier which, at the time it came, was a 0.1% device. They knew that if the filter were changed the dynamic response could be varied quite a bit. They even requested a plug-in filter at the time. So the 0.1% specified for static accuracy didn't mean anything and they realized it.*

Dov does not agree that time-division multipliers in general are no good. Pomona has computer problems which they could not solve without electronic multipliers. However, the electronic multipliers are by no means a panacea—most operators prefer servos when they can use them.

Dov thinks it somewhat unfair to say that the customers fall for this 0.01%—0.02%. He has evaluation charts which they prepared on an electronic multiplier before purchasing it and the list of factors is two pages long. Only one of the factors was static accuracy.

At Bernie's invitation, *Stan Rogers* stated his position, saying that he deliberately did not name the equipment about which he spoke, although the context may have added a name to it. The equipment belongs to the Astronautics Division of Convair. After talking to Bernie on the subject in New York, Stan checked back with the users and found they were still happy with the equipment. At the frequencies which they are using, it is still behaving to their complete satisfaction.

"Contrary to your interpretation of my remarks," Stan continued, "I did not in any sense intend them to be an endorsement of any vendor's product. I was making comparisons between very modern gear which we have just received and gear of earlier vintage. I think that is a perfectly valid comparison."

By way of summing up, *Norm Irvine* said he was in full accord with nearly everything Bernie said. Actually the question of how to evaluate different computer components was discussed at the Western Simulation Council some time ago, and it was found that users do not agree, so "how can we expect vendors to agree?"

*Joe Hussey** rose to the occasion by suggesting that "rather than hassle about it, we vendors get together."

Analog-Computer Multiplier Committee

As a result of all this discussion, the Western Simulation Council sponsored the formation of an "Analog Computer Multiplier Committee" made up of the following members:

DOV ABRAMIS, Chairman, Convair-Pomona

RICHARD ANDERSON, Dynalysis Dev. Labs, Los Angeles

ARTHUR BRIDGMAN, Sylvania Electronics Defense Lab, Mountain View, Calif.

HANK FLUM, Reeves Instrument Corp., Santa Monica

JOHN A. HERREL, Goodyear Aircraft Corp., Los Angeles, or NICK COLLETTI, Goodyear Aircraft, Akron

ROBERT HORWITZ, Convair-Astronautics, San Diego

JOSEPH HUSSEY, Berkeley Div., Beckman, Richmond, Calif.

NORMAN IRVINE, Mid-Century Instrumatic, Los Angeles

GEORGE JACOBI, General Electric, Phoenix

WILLIAM KINDLE, Electronic Associates Computation Center, El Segundo

HANS MEISSINGER, Hughes Aircraft, Culver City, or DUANE BEECHER, same company

STANLEY ROGERS, Convair-San Diego

JACK SHERMAN, Lockheed Missile Systems Div., Palo Alto

This committee will attempt to examine all current test procedures and specifications of both servo and electronic multipliers. Sample tests will be conducted by committee members using current methods and new ones as suggested by and to the committee. As an end product, the committee hopes to prepare a written survey of test procedures and possibly recommend uniform procedures for consideration by the Simulation Councils and the various analog-computer manufacturers.

The committee has already held three meetings and is making good progress. Their methods and accomplishments will be reported in some detail in the next Newsletter.

Tour of Lockheed MSD

The March 14th meeting of the Western Simulation Council was followed by a tour of the Lockheed Missile Systems Division computing facility. According to *Jack Sherman*, the "new laboratories are ideally located on a knoll overlooking the city of Palo Alto and San Francisco Bay." They are in the recently created Stanford Industrial Park, one mile south of Stanford University.

Jack was more fortunate than most in being able to specify certain features in the buildings before they were erected. For example, the analog computer room is built on a specially reinforced hardwood floor 18″ above the concrete subfloor. All fans have been removed from the computer cabinets, and the computer is cooled by introducing conditioned air into the room at 68°F, forcing it down through the computer cabinets, and exhausting it out under the floor. The result is a neat, clean installation which is unusually quiet.

* The multiplier in question is vintage 1951-52. Since 1953 Reeves has been manufacturing diode square-law electronic multipliers—Bernie L.

* Joe's "Suggested Multiplier Specifications" appeared in the Newsletter of April, 1953. Those of Dick Baum (Goodyear Aircraft Corp., Phoenix, Arizona) appeared in the issue for March, 1953.) We only mention this to show we anticipated Bernie's complaint by several years. In case our readers would like copies of the suggested specs, they are out of luck. Sorry, only copies left are in our archives.

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Simulation Council

CONTINUED

Sixty-cycle 117-volt power is supplied by a 125 KVA motor-generator set which furnishes power to the analog computer only. Jack says that this has finally licked the problem of fluctuation in the line voltage because the generator is driven by a 150-hp synchronous motor, the speed of which depends on the frequency of input voltage and not on its magnitude. Even if it were not synchronous, the inertia of the armatures would smooth out most short-term transients.

"I think," added Jack, warming to his subject, "That it is interesting to note than when a forward-looking company like Lockheed MSD establishes a facility especially for research and development it is wise enough to provide its technical people with one-, two-, and three-men offices instead of herding them into huge 'bull-pens' like most of the aircraft companies."

Information (Without Theory)

Whaddayaknow? *Don Byck* isn't dead* after all—he was just on vacation. On his return, he sent us a copy of the paper we mentioned, but it's too technical and too long for inclusion here.

The paper, entitled "Simulation of Linear Constant Coefficient Systems by the Weighting Function Technique," treats of some practical applications of the weighting function technique for instrumentating integrodifferential equations. Points covered include, "Methods of Describing Linear Constant-Coefficient Systems," "Weighting Functions," "Unit Impulse," "Analog Simulation by the Weighting Function Technique," and two methods for "Instrumentation of the Convolution Operation." "Noise Studies by the Weighting Function Technique" are discussed, and reproductions of recordings made using the methods described are included.

Practical applications of the techniques include analog computer generation of amplitude and phase frequency-response data and Gaussian random input data.

If you are interested, Don might send you a copy. His address is Princeton Computation Center, Electronic Associates Inc., Box 582, Princeton, New Jersey.

* * *

We also received a copy of a paper "Bi-Variable Function Generation" by *Joseph R. Levitt* (Missile & Surface Radar Engineering, Bldg. 108-1 RCA, Moorestown, N. J.). The covering letter states in part: "The April issue of the Simulation Council Newsletter was especially interesting in its review of the Western S/C meeting of January 10. In particular, Bill Kindle's technique for generating a function of two variables caught my attention at once. The reason for this interest is that Kindle's technique appears to be virtually identical to that which I devised well over a year ago. After employing it successfully in a wide variety of simulation problems, I presented the technique in a paper delivered at the AIEE Winter General Meeting in New York. The only essential difference that I can detect is that my method does not require an iterative approach . . . . I am enclosing a copy of this paper. I will be happy to send additional copies to your readers if they request it."

* As suggested in last month's writeup of the February meeting of the Southeastern Simulation Council.

Computer Events

Eastern Simulation Council

Date: 15 July, 1957

Place: Rensselaer Polytechnic Institute, Troy, N. Y.

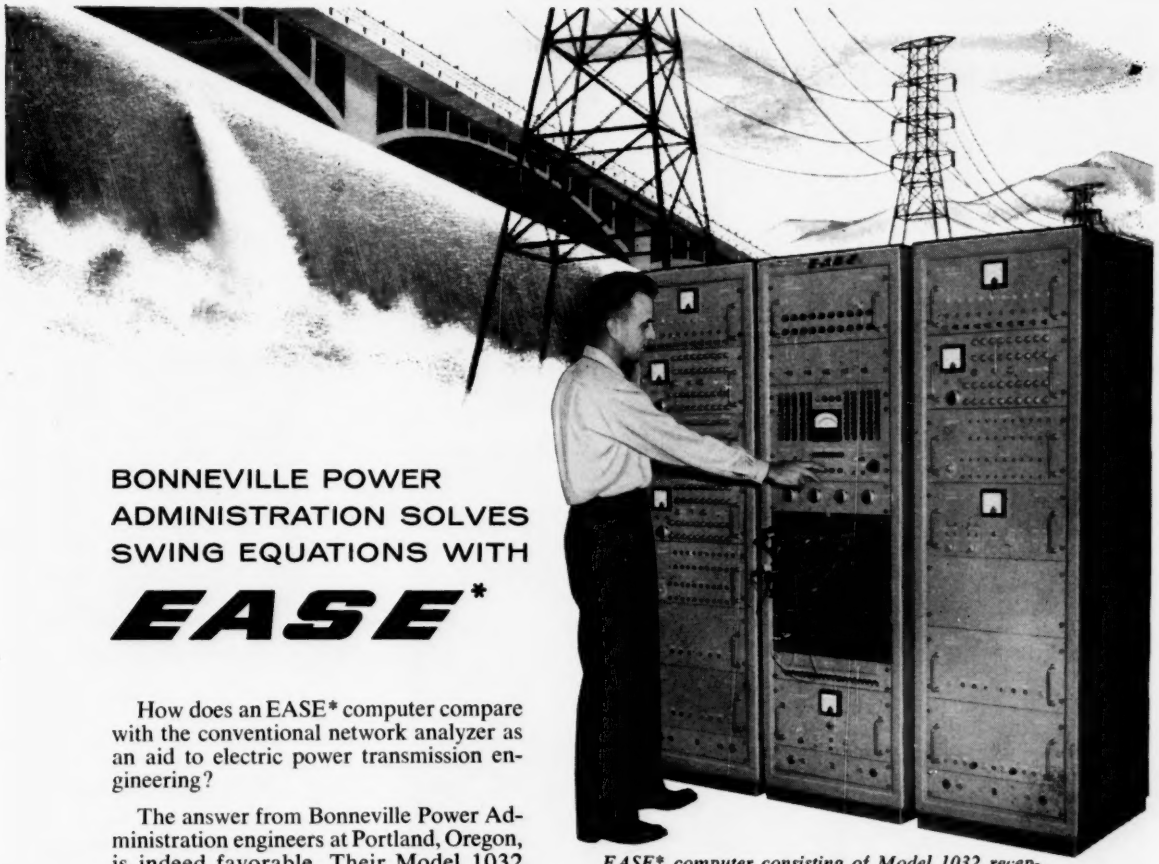
Subject: Digital Differential Analyzers. Schedule: 10 AM—Steering Committee and Tour; 11 AM—Study groups; 12 Noon—Lunch; 1 PM—Technical sessions

Symposium on Analog and Digital Computation and Systems Dynamics

Dates: 19—20 November, 1957.

Place: Wright Air Development Center, Wright-Patterson Air Force Base, Ohio.

There will be one combined session on topics of interest to all groups, followed by separate meetings on digital computation, analog computation and system dynamics. For information write A. C. Robinson, Aeronautical Research Laboratory, WCRRY, Wright Air Development Center.



BONNEVILLE POWER ADMINISTRATION SOLVES SWING EQUATIONS WITH

EASE*

How does an EASE* computer compare with the conventional network analyzer as an aid to electric power transmission engineering?

The answer from Bonneville Power Administration engineers at Portland, Oregon, is indeed favorable. Their Model 1032 EASE* has proved infinitely faster in the solution of swing equations and in studies of transient and steady-state problems of the vast Northwest power network.

EASE computer consisting of Model 1032 receptacle-control, 6 function generators and 20 amplifiers, installed at Bonneville Power Administration engineering offices, Portland, Oregon. Chief engineer is E. C. Starr; computer and systems engineer is Carl Gustafson.*

Interconnecting four of the world's largest hydroelectric projects and hundreds of fast-growing communities, this high-voltage (230 KV and up) network presents complex problems in stability. Speedy problem solution on the EASE* has already enabled BPA engineers to improve system stability, eliminating many outage problems, and to plan a variety of alternate switching paths to minimize circuit downtime.

Indications are that this EASE* installation has already paid for itself, with rosy prospects for a profitable future. Among coming studies BPA engineers plan for the versatile EASE* are:

1. Effect of machine excitation on system performance
2. Hydraulic governor speed control
3. Design problems in mechanical, civil and electrical engineering related to system improvement and future expansion

Good field service is a vital factor in satisfactory computer performance. It is supplied with EASE* by a nation-wide network of factory-trained Berkeley representatives; in this instance, Hawthorne Electronics of Portland and Seattle.

EASE* computation and simulation equipment ranges from the basic Model 1032 illustrated here to the advanced-design Model 1132 with DO/IT (Digital Output-Input Translator system). Two fully-equipped EASE* computation centers (Los Angeles and here at Richmond) are also available on a "for hire" basis. Full information on EASE* equipment and facility services is yours for the asking; please address Dept. B-6.

127

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Beckman®

Berkeley *Division*

Richmond 3, California

a division of Beckman Instruments, Inc.

For more information circle **74** on inquiry card.

INSTRUMENTS and AUTOMATION

New Instruments

CONTENTS OF THIS DEPARTMENT

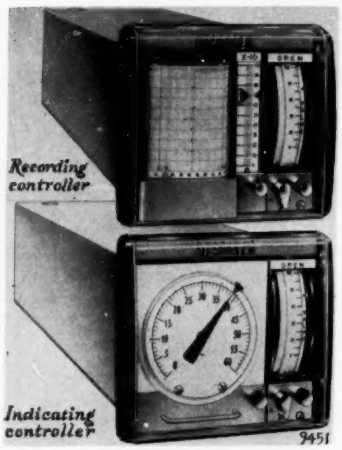
Amplifiers	1185	Electronic Instruments	1181	Power Supplies	1186
Computing	1161	Flow-rate	1155	Pressure	1145
Data Processing	1161	Force, Displacement, Vibration	1152	Process Measurement and Control	1142
Electrical-instrument Accessories	1179	Inspection	1175	Shop Equipment and Materials	1172
Electrical Instruments	1181	Laboratory Equipment	1169	Temperature	1147
Electrical Testing	1178	Mechanical Testing	1176	Vacuum	1145
Electromechanical Components	1166	Miscellaneous	1190	Valves	1157
Electronic Components	1188	Photography	1168	Volume	1155

FOR FURTHER INFORMATION USE THE POSTAGE FREE ORDER CARD ON PAGE 1217

PROCESS MEASUREMENT and CONTROL

ELECTRONIC CONTROLLERS

New electronic controllers can be interchanged at panelboard in seconds; allow changeover from recording to indicating type, proportional-

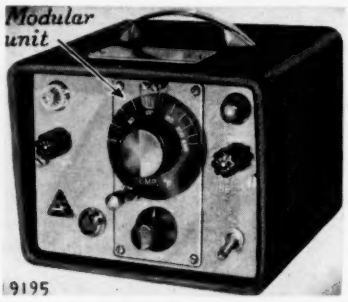


action to proportional-plus-reset action, slow reset to fast reset. Replacement is made by simply pulling one unit out and plugging-in the other. Controller settings are all calibrated and repeatable. When controller station is replaced, proportional, reset and rate settings can be made in advance so that process is on control at once.—*Manning, Maxwell & Moore, Inc., Stratford, Conn.*

For more information circle **201** on inquiry card.

PROCESS CONTROLLER

New "Model 6365" features easy change from standard to special temperature ranges, or conversion to pressure, displacement, or other process variables; features balanced-bridge circuitry in a modular front-

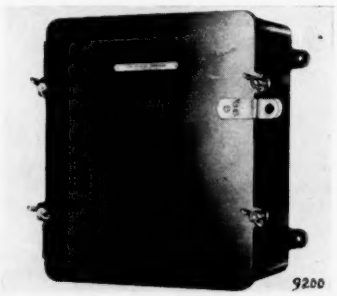


panel unit which can easily be removed and replaced with another unit of different characteristics. Basic control mechanism is an electronic switch housed in a standardized aluminum case. Standard model, for temperature control, offers control sensitivity of 1 F° in standard (0°F to 250°F) temperature range. On special order, matched bridge-module and primary-element system is capable of temperature control within 0.5F.°—*Autron Engineering, Inc., 1254 W. Sixth Street, Los Angeles 17, Calif.*

For more information circle **202** on inquiry card.

WEATHERPROOF RECORDERS

New models of maker's 8" and 12" round-chart recording gages for pressure, vacuum, and water or liquid

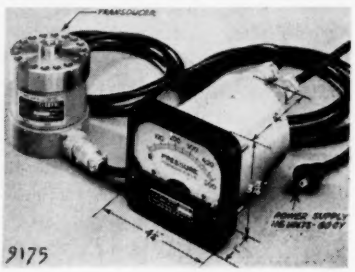


level measurements are available in weatherproof cases, for wall or pole mounting outdoors.—*The Bristol Co., Waterbury 20, Conn.*

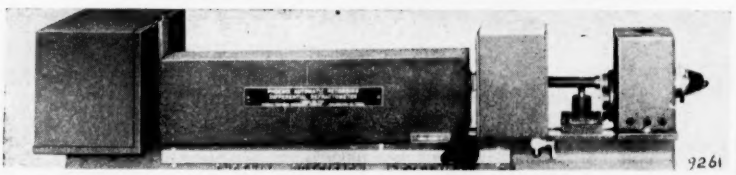
For more information circle **203** on inquiry card.

INDICATING SYSTEM

New "Model 182 Teledyne Indicator" for indicating telemetered information from strain-gage type pickups comprises a precision dc millvoltmeter



PHOTOELECTRIC-TYPE PROCESS REFRACTOMETER



New photoelectric refractometer for lab, pilot plant, or process control, utilizes null method with a small quantity of the desired fluid (liquid or gas) placed in a comparison cell. Feature: refined self-nulling optical servo system which requires no electrical feedback from the process: small continuous flow of process fluid through one half of reference cell provides control stimuli. Output signal is linear, simplifying both (1) integration into present or proposed systems and (2) actuation of recording and data-processing equipment.—*Phoenix Precision Instrument Co., Inc., 3803-95 N. 5th St., Philadelphia 40, Pa.*

For more information circle **204** on inquiry card.

movement and dc power supply which furnishes excitation to the pickup; can be used for measurement of load, pressure, thrust, torque, etc. Instrument accuracy 1% of full-scale; over-all system accuracy 2%. Indicator can be graduated in any standard units; special dials can be furnished. Maker maintains a special service dep't for "Teledynes."—*Section 75, Taber Instrument Corp., North Tonawanda, N. Y.*

For more information circle **205** on inquiry card.

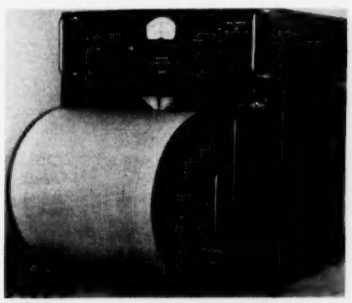
SUPERVISORY AND REMOTE CONTROL SYSTEM

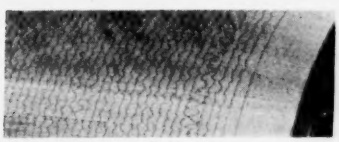
New "ERX" (electronic remote switching) supervisory control system allows more than 1000 different codes to be transmitted over a single two-way channel; will control and continuously supervise hundreds of functions at remote locations; is capable also of alternate use with teletype; is particularly suited for control of pipe lines, power stations, etc., where operators at one or more locations can control equipment at distant points and get positive identification that each job is done. Claim is made that "It will do far more than previous equipment, yet represents a simplification of components, is substantially smaller in size, has lower power requirements and costs less."—*Hupp Electronics Co., 743 Circle Ave., Forest Park, Ill.*

For more information circle **206** on inquiry card.

KYMOGRAPH-TYPE RECORDER

New "Model 2484 Helicorder" features frequency response of dc to 35 cps, high resolution, and ultra-compact easily-read records. As much as 1360 ft of continuous record can be made on a single sheet of heat-sensitive paper, 38" by 11-⅞" (see close-up). Paper speed and trace separation are controlled by change gears. During operation, two-thirds of recorded trace is always visible from the front. ★ Matching "Model 2480" amplifier couples "Helicorder" to signal line, providing voltage and power amplification.—*The Geotechnical Corp., 3712 Haggar Drive, Dallas 9, Texas.*





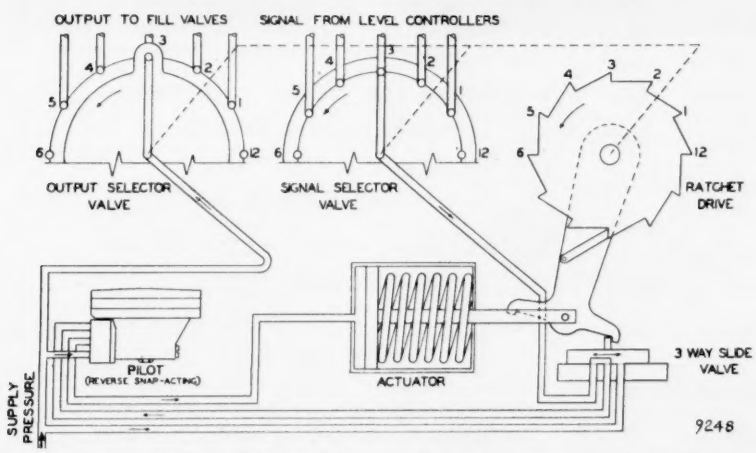
For more information circle **208** on inquiry card.

PNEUMATIC CONTROLLER

New "Transcope" makes unique use of motion-balance principle through interconnected multiple bellows and springs acting on a common force plate. Plug-in feature with integral cut-off relay makes possible mounting to a separate manifold located at point of measurement or point of control. Among other features: conversion from single to multiple control responses or vice versa easily accomplished even in the field; low air consumption.—*Taylor Instrument Companies, Rochester 1, N. Y.*

For more information circle **209** on inquiry card.

AUTOMATIC MULTI-TANK CONTROL SYSTEM

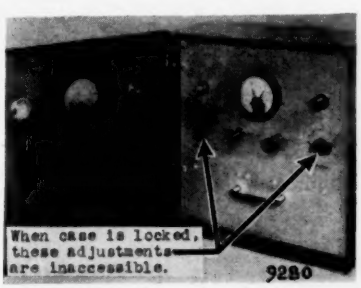


New "Automatic Tank Selector System" is of pneumatic type, comprises a "Selector-Controller" and level transmitters directing operation of pneumatic fill valves. In operation, "Selector-Controller" receives pneumatic signal from each level transmitter and automatically opens fill valve if tank requires filling, or automatically cycles to next tank if filling is not required. Scanning operation can be continuous or intermittently cycled (one second per tank.) One "ATS Circuit" handles up to 12 tanks; two or more "Selectors" can be connected in series to control any number of tanks.—*Mason-Neilan, 60 Nahatan St., Norwood, Mass.*

For more information circle **207** on inquiry card.

OVERLOAD ALARM AND TRIP

New "Monitron" gives maximal protection of automatic machinery against damage arising from load changes. It continuously monitors power drawn by any electrically-driven machine. Power changes beyond predetermined limits cause "Monitron" to trip: a red trip-warning light flashes and a relay starts any de-



BISHOP TUBING

is used in BAILEY METER COMPANY RECORDING INSTRUMENTS

Photograph, Courtesy Bailey Meter Co., Cleveland, Ohio

Bailey Meter Company selects Bishop *quality* #321 Seamless Stainless Tubing with a .125" O.D. x .010" I.D. for accurate, dependable and lasting performance.

In fact, almost all leading instrument makers use Bishop tubing in their products today.

When you need tubing LOOK NO FURTHER FOR QUALITY . . . specify Bishop tubing.

SEAMLESS AND WELDED AND DRAWN STAINLESS STEEL TUBING
(.008" to 1.000" O.D.)
(.003" to .083" Wall)

MECHANICAL, CAPILLARY, HYPODERMIC and AIRCRAFT GRADE NICKEL AND NICKEL ALLOY TUBING
(up to .625" O.D.)

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JB

STAINLESS STEEL PRODUCTS DIVISION

J. BISHOP & CO. Platinum Works

Malvern, Pennsylvania

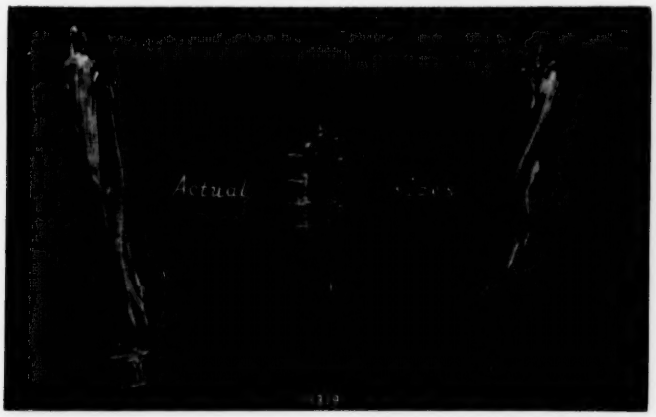
For more information circle **75** on inquiry card.

sired control function in auxiliary equipment. "Monitron" is easily installed; requires no attention beyond pre-setting load limits. It will operate in conjunction with any single- or three-phase 60-cps ac, 115-, 220-, 440- or 500-v motor of ¼ to 95 hp when current input, measured under actual load, is between 1 and 30 amp.—*Sperry Products, Inc., Shelter Rock Road, Danbury, Conn.*

For more information circle **210** on inquiry card.

PRESSURE AND VACUUM

FUSED SILICA PRESSURE-MEASURING ELEMENTS

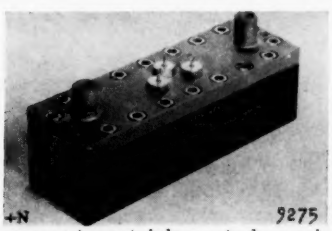


New elastic-deformation-type pressure-measuring elements, made from fused silica, are available in two basic forms: bellows (single or multiple convolution) and twisted tubes. Production methods nearly eliminate hand manipulation and permit quantity production of a uniform product. The three-convolution bellows shown has a sensitivity of 0.0001" elongation per psig, 5 atmospheres safe working pressure. The twisted tubes shown have a sensitivity of 0.2° rotation per atmosphere; other sizes and sensitivities available. ★Fused silica has an almost immeasurably low hysteresis and a useful temperature range from −200°C to 800°C; is highly resistant to corrosion. Designers of pressure instruments will be able to "take advantage of these characteristics to produce instruments superior to those presently available."—*Emil Boblett Co., P. O. Box 666, Manhattan Beach, Calif.*

For more information circle **211** on inquiry card.

PRESSURE PICKUP

New "Model H," said to operate accurately under vibration environments to ±20 G and temperatures to 400°F,

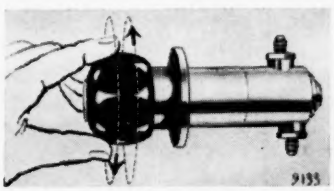


incorporates stainless steel sensing elements which permit use of corrosive fluids. Internal resonances are eliminated, friction effects are minimized, and extremely long resistor life achieved by use of a special damping fluid. Case burst pressure 7500 psi. Available in ranges from 1000 to 10,000 psig or psid.—*Servonic Instruments, Inc., 1145 South Fair Oaks Ave., Pasadena, Calif.*

For more information circle **212** on inquiry card.

REGULATOR & RELIEF VALVE

New "Hi-Lo Hand Loader" adjustable pressure regulator and relief valve for controlling gases such as



helium, nitrogen and compressed air, under pressures from 100 to 3000 psi, is of zero-bleed internal-venting type. Adjusting control knob clockwise provides for pressure regulation, and counterclockwise for pressure relief over entire 100-3000-psi range. Thus, unit can be used for operations where both pressure regulation and relief are required. Flow equivalent to 0.125"-dia sharp-edge orifice.—*Futurecraft Corp., 1717 N. Chico Ave., El Monte, Calif.*

For more information circle **213** on inquiry card.

for RELIABLE MONITORING in Hazardous Locations...

EXPLOSION-PROOF ANNUNCIATORS (Type EKP-4)

Wherever processes or systems in hazardous locations must be monitored with unwavering safety, consider Scam Explosion-Proof Annunciators. These rugged alarms provide a sturdy housing that is approved for Class I, Division I, Group D locations.

INCLUDES ALL THESE SCAM FEATURES:

- Four alarms in one housing...requires little piping, low installation costs!
- Standard for "Sequence A" (visual-audible), other sequences on special order!
- All relays mounted on plug-type jack . . . for maintenance just plug spare jack into housing!
- Only four holes required for easy panel mounting!

For Constant Protection for Your Monitoring Needs, Choose a Scam Explosion Proof Annunciator.

For special Explosion Proof Systems, consult with us or one of our representatives.

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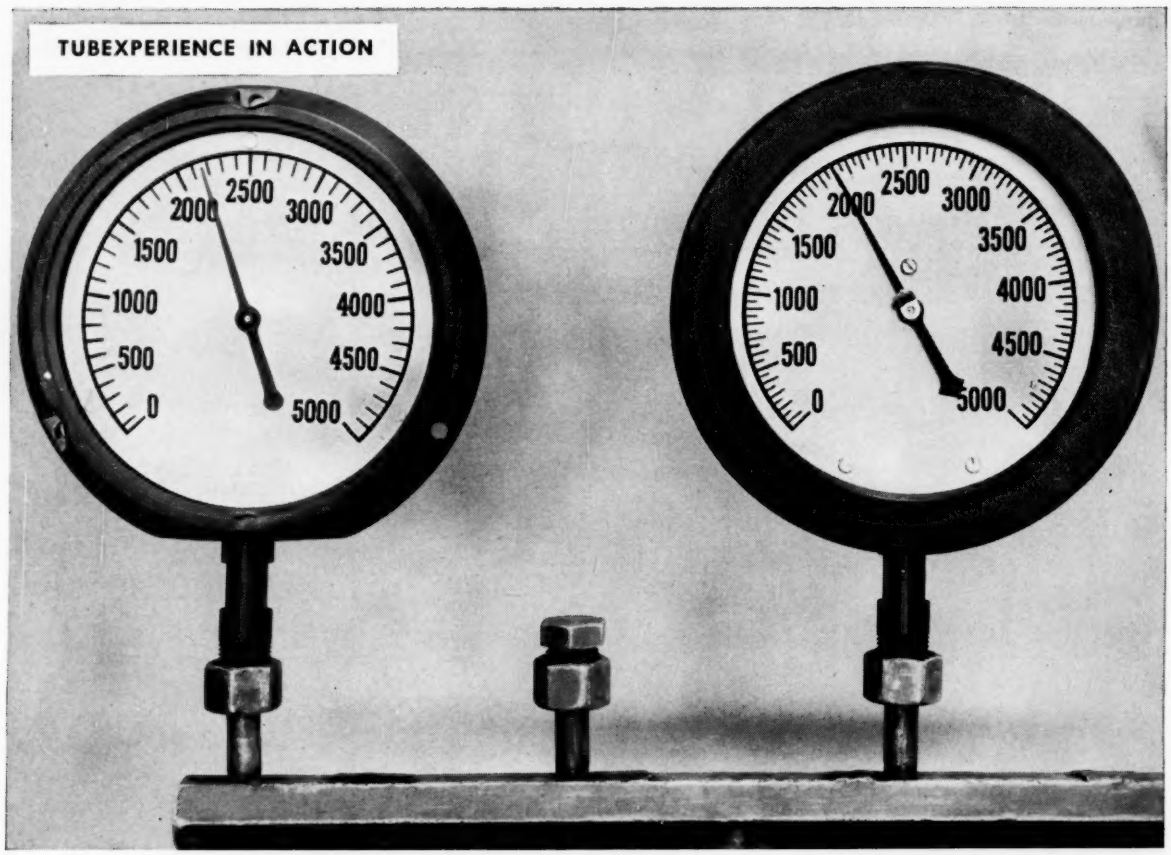

Q. Which gage tells the truth longer?

A. *The gage with the Superior extra-quality Bourdon tube*

HERE'S WHY—

Quality cannot be inspected into tubing. Thus at Superior the quality is built in from start to finish. Stock for redrawing is carefully selected and prepared. Superior's method of producing Bourdon tubing includes many special techniques, developed through years of "tubexperience." Such factors as surface quality, close dimension control, freedom from decarburization, accurate shaping and cleanliness, all combine to produce a Bourdon tube of unexcelled quality.

Cheap Bourdon tubing no economy. Why risk having your gages fail or lose their accuracy? Inferior quality Bourdon tubing will crack, develop leaks, or take a set long before Superior's will show any signs of wear.

Quality Bourdon a must. The Bourdon tube represents only a small fraction of the total cost of your gage, yet it is the most important single element. Be sure to get only the best Bourdon tubing available.

Specify Superior. There are 8 different Bourdon analyses to choose from, including Ni-Span C. Flat ovals, ellipticals, rounds and partial rounds, etc. For technical data on Superior extra-quality Bourdon tubing, write for a free reprint of "Bourdon Elements Require Special Tubing." Superior Tube Company, 1968 Germantown Ave., Norristown, Pa.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to ⅝ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Co., 5710 Smithway St., Los Angeles 22, Calif. • RAymond 3-1331

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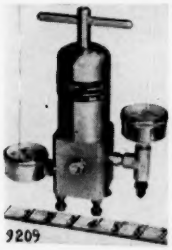
PRESSURE REGULATOR



New "2840100" manually-operated pressure regulator is designed especially for use in lab, or in conjunction with air compressors. Inlet accepts stored air pressure up to 3500 psi; adjusting handle regulates delivery pressure continuously from 0 to 3000 psi. Integral relief feature permits upward or downward adjustment of delivery pressure without separate relief of delivery pressure line.—*The Cornelius Co., 550-39th Ave., N.E. Minneapolis 21, Minn.*

For more information circle **214** on inquiry card.

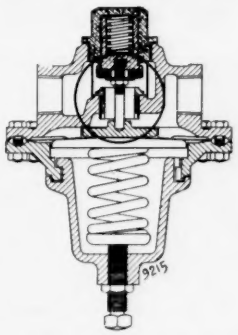
DUAL PRESSURE CONTROLLER

New "Type J75A" dual switch pressure controller contains two completely separate switches that operate independently of each other for controlling two independent circuits; offers extreme flexibility of switch arrangement; is available in seven models with adjustable ranges between 0 and 250 psi limits; maximum pressures up to 350 psi; and on-off switch differentials between limits of 5 and 10 psi. Pressure settings are made by independent adjustment screws. Switches can be set together to simulate double-pole circuitry or set apart to obtain independent operation.—*United Electric Controls Co., 79 School St., Watertown, Mass.*

For more information circle **215** on inquiry card.

PRESSURE REGULATOR

Newly improved pressure regulator incorporates a larger through passage which gives a greater capacity



and also a less turbulent flow pattern through valve. Valve's construction is simpler and valve discs are now interchangeable, so that user can quickly switch from water service, for example, to steam, gas or air. Added safety factor: spring adjustment from below rather than from above as in previous models. Reduced pressure range 1 to 100 psi, depending on valve size, with initial pressures as to 400 psi. Bronze, semi-steel, or steel body; special alloy trim if desired. Standard sizes ⅜" to 2".—*Davis Regulator Co., 2545 So. Washtenaw, Chicago 8, Ill.*

For more information circle **216** on inquiry card.

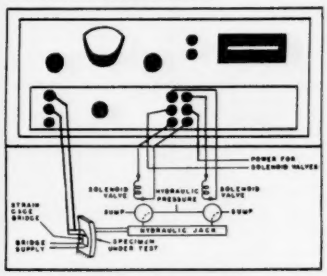
PRESSURE SNUBBERS

New ⅛" NPT size porous metal type snubbers, with male and female pipe connections, are fabricated of brass, aluminum or stainless steel for maximum corrosion resistance; and in porosities for oil, water and gases.—*Chemiquip Co., 460 W. Broadway, New York 12, N. Y.*

For more information circle **217** on inquiry card.

FOR
Automatic Control
OF TEST LIMITS
USE THE
SPAR
PROGRAMMER
COUNTER

The SPAR Programmer Counter is a precision unit that eliminates manual control of test cycling and simplifies the setting up of equipment each time a test is to be made.



The SPAR Programmer Counter is a compact, precision-made device that automatically turns on and off test apparatus whose limits are sensed by strain gages, thermocouples or any other transducers that have a maximum output not exceeding 100 millivolts DC. It simplifies the setting up of equipment each time a test is to be made and eliminates the need for manual control of test cycling. A counter, which may be of the preset type, registers each cycle.

- **The unit, which operates on 110V AC, is a stable, precision, millivolt electronic relay having adjustable energizing and release thresholds and DPDT 15 amp contacts.**
- **Two, adjustable, stable thresholds provide for precise selection of upper and lower operating limits.**
- **Models can be obtained with up to 5 sets of adjustable limits with automatic switching by preset counters.**

SPAR Bridge Power Supply Unit...

This unit for supplying power to bridges and strain gages is regulated and filtered by transistors. It has an extremely low ripple. Output is 0 to 25 DC up to 400 milliamperes.

Write, wire or call for full details on this SPAR equipment

Spar **ENGINEERING and DEVELOPMENT** INCORPORATED

all electronic programming and control systems, radiant heat programming systems

WYNCOTE, PA. • TUrner 6-5350

For more information circle **78** on inquiry card.

TEMPERATURE AND HUMIDITY

ST-STEEL THERMOSTAT

New "Model 18000-26 Thermoswitch," for corrosive applications, is fabricated entirely from 316 stainless

steel and all exterior joints are heliarc welded. Control range −100 to 400°F. Short-time overshoot by as much as 100 F degrees will not affect reliability. New thermostat will control within 2 F° in a well-designed system. Rating 10 amp 115 vac or 2 amp 115 vdc.—*Fenwal Inc., Ashland, Mass.*

For more information circle **218** on inquiry card.

EMBEDDED THERMOCOUPLES

New "Delta-Couples," said to offer solutions to advanced industrial and military instrumentation requirements, measure temperatures at precise in-wall locations (0.003" or closer); employ novel technique of embedding ribbon junctions in "weld nuggets" at selected depths in ¼" threaded plugs of steel and aluminum. Features: small size, adequate

Motor - Gear - Trains

3:1 to 150,000:1 Ratio Range • Up to 18 Foot Pounds Torque

- Motors available: DC, 60 or 400 cycle, PM, split series, series, shunt, single phase and 2-phase. All are reversible.
- Available with either governor or brake.
- 1000 hour life minimum.
- Designed to meet MIL-E-5272A.
- Precision gearing throughout.
- Can be furnished up to 125°C.
- Designed for continuous duty or intermittent duty applications.

MOTOR GEAR TRAIN													
Gear Ratio	No-Load Speed	Nominal Voltage D.C.	Voltage Range D.C.	No-Load Current	Normal Speed	Normal Load OZ.IN.	Normal Current	Operating Temp. Range	Size	Overall Length Inches-Max.	Motor Type	Mounting	Oster Type
5.68:1	1800	28	24-32	0.4	1800	5.0	1.0	−55° To +85°C	13	3.777	P.M. GOVERNOR	FACE	13R-9102-08
17.9:1	600	28	24-32	0.4	600	12.0	1.0	−55° To +85°C	13	3.930	P.M. GOVERNOR	FACE	13R-9102-06
32.3:1	300	28	24-32	0.4	300	12.0	1.0	−55° To +85°C	13	3.935	P.M. GOVERNOR	FACE	13R-9102-02
67:1	150	28	24-32	0.4	150	12.0	0.6	−55° To +85°C	13	4.092	P.M. GOVERNOR	FACE	13R-9102-05
85:1	150	27.5	—	.25	130	50.0	0.7	−55° To +85°C	13	4.095	P.M.	FACE	13R-9101-11
109:1	100	28	24-32	0.4	100	32	0.6	−55° To +85°C	13	4.094	P.M. GOVERNOR	SYNCHRO	13R-9102-12
109:1	180	27.5	—	0.4	175	30	0.5	−55° To +100°C	13	2.843	P.M.	FLANGE	13R-9104-01
125:1	75-90	28	—	.25	70-85	20	0.3	−55° To +71°C	13	3.920	P.M.	FACE	13R-9101-13
157:1	60	28	24-32	0.4	60	12.0	0.6	−55° To +85°C	13	4.095	P.M. GOVERNOR	FACE	13R-9102-03
285:1	48	35	—	.25	40	160	0.6	−55° To +71°C	13	4.038	P.M.	FACE	13R-9103-01
333:1	30	28	24-32	0.4	30	12.0	0.6	−55° To +85°C	13	4.317	P.M. GOVERNOR	FACE	13R-9102-04
410:1	15	27	25-29	0.3	15	8.0	0.3	−55° To +85°C	13	4.400	P.M. GOVERNOR	FACE	13R-9102-11
1043.8:1	5-10	27	24-30	0.15	7	30	0.2	−55° To +71°C	13	4.450	P.M. BRAKE	FACE	13R-9105-01
1044:1	5-10	27	24-30	0.15	7	30	0.2	−55° To +71°C	13	3.910	P.M.	FACE	13R-9101-12
2214:1	3-4	6	—	1.2	3.4	30	1.2	−55° To +71°C	13	4.454	P.M.	FACE	13R-9101-04
3241:1	5.5	35	—	.35	5.5	18	0.4	−55° To +71°C	13	4.454	P.M.	FACE	13R-9101-03
5933:1	1.3	30	—	.13	1.3	30	0.15	−55° To +71°C	13	4.816	P.M.	FACE	13R-9101-10
21,707:1	2-3	120	—	.25	2-3	12	0.25	−55° To +71°C	13	3.475	P.M.	FLANGE	13R-9101-16
322:1	80	110	—	0.2	30	240	0.3	−55° To +71°C	15	3.815	SPLIT SERIES	FLANGE	15R-9201-01
407:1	22	27	—	0.2	20	8	0.2	−20° To +50°C	15	3.989	SPLIT SERIES	SYNCHRO	15R-9201-03
433:1	30	26	—	0.6	25	260	1.2	−50° To +80°C	15	3.110	SHUNT	FACE	15R-9201-02
955:1	33	27	—	0.6	12-18	420	1.0	−55° To +50° C	15	4.419	SPLIT SERIES	FLANGE	15R-9201-08
26:1	240	27.5	24-29	0.65	240	40	1.3	−18° To +71°C	17	5.315	SHUNT GOVERNOR	SYNCHRO	17R-9251-01
4.26:1	1800	28	—	0.6	1800	12	1.85	−30° To +55°C	24	4.640	SHUNT GOVERNOR	FACE	24R-9451-01

Speed tolerance on governed motors is ±2% over voltage and an ambient temperature range. Closer speed tolerance units can be designed to fit the particular application.

Many other variations available. There is an Oster motor-gear-train to fit your exact specification. Consult Oster specialists today, sending your detailed requirements.

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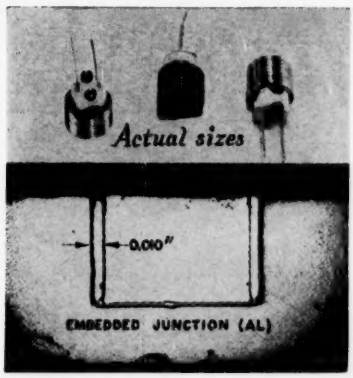
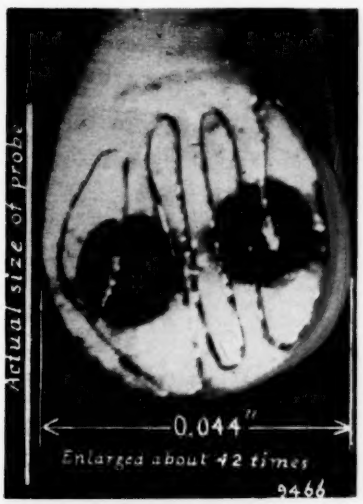


output, minimum disturbance of heat flux, simultaneous response with the wall material, and wide temperature range (e.g. −50°C to 1000°C in steel; −50°C to melting point in aluminum). Special configurations and other materials to order.—*Detroit Controls Corp., Research Dept.,* 1650 *Broadway, Redwood City, Calif.*

For more information circle **219** on inquiry card.

TINIEST RESISTANCE THERMOMETRIC PROBE

New high-temperature resistance-thermometer probe (upper limit 1200°C or 2200°F) utilizes a grid of extremely fine platinum wire welded to platinum lead wires; is believed to

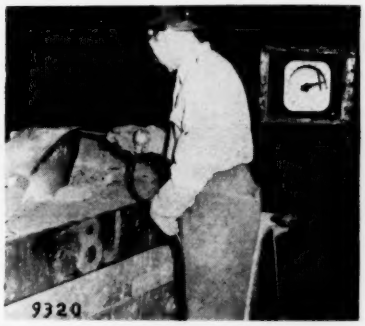


be first with a flat grid temperature element wound on end of a one-millimeter tube. Grid lies in one plane on end of double-bore porcelain tube about 0.044" at base. Grid resistance 12 to 16 ohms at room temperature.—*Arthur C. Ruge Associates, Inc.,* 733 *Concord Ave., Cambridge* 38, *Mass.*

For more information circle **220** on inquiry card.

IMMERSION THERMOCOUPLE

New thermocouple for high-temperature molten-metal measurements up to 3100°F uses a metal-ceramic LT-1 secondary protecting tube, a vitrified alumina primary tube, and a platinum 10% rhodium thermocouple. A curved stainless steel tube of any required length leads to a wooden grip and thermocouple assembly head. Standard model will have 8 ft of armored connecting wire. All parts are stock items. Life tests indicate that secondary LT-1 tube will normally withstand about ten dips in molten

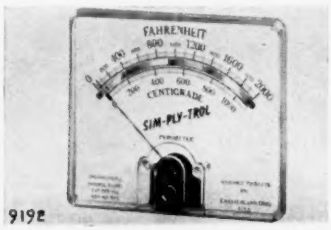


steel between 2700 and 3100°F. Lower temperatures will give proportionally longer life. ★Also available in a High Speed model with a single quartz protecting tube. Conversion between models is simple and fast.—*The Bristol Company, Waterbury* 20, *Conn.*

For more information circle **221** on inquiry card.

MIRROR-SCALE PYROMETERS

New models of maker's indicating pyrometers can be read accurately from all angles because they have

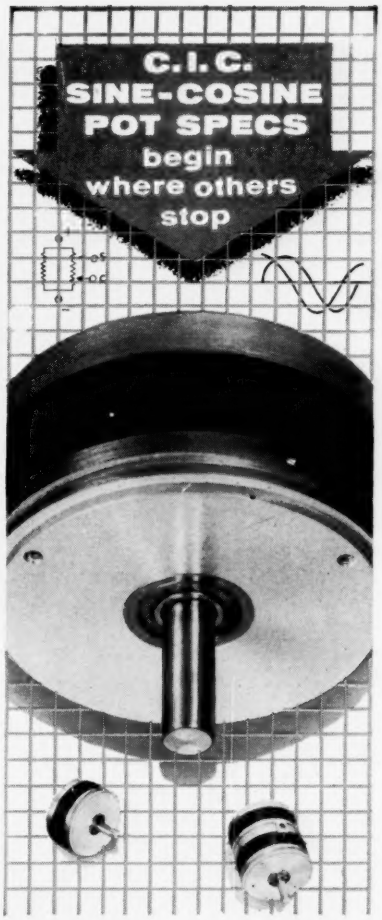


been redesigned with mirror scales to cut down parallax effects. They are 3-¾" and 4-½" wide medium-resistance millivoltmeters (4 ohms/mv), available in 21 standard ranges. Maximum sensitivity for a pyrometer connected to one thermocouple is 300 F degrees for full-scale deflection. Standard ranges begin with −400°F to 100°F and up to 0-3000°F.—*Assembly Products, Inc., Wilson Mills Rd., Chesterland, Ohio.*

For more information circle **222** on inquiry card.

SURFACE PYROMETER

New low-cost surface pyrometer checks surfaces as small as ¼"; has accuracy of 2% of scale span; weighs 1½ lb; is chrome-plated throughout to prevent absorption of heat that



Infinite resolution and absolute dependability distinguish CIC ultra-precise Potentiometers. In the generation of the sine wave CIC Pots provide smooth, reliable performance, distortion free at all angles of rotation.

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For more information circle **80** on inquiry card.

The need to compromise on panel instrument quality is now a thing of the past. Model 1301 Weston Cormag instruments cost no more, often less, than the compromise types. Thus you can get the *big increment of dependability* which Weston instruments provide for all your panel and built-in needs; *plus* the other advantages of Weston's core-magnet, self-shielding construction. For example, they can be mounted closer together on a panel without intereffect . . . and used interchangeably on either magnetic or non-magnetic panels. Let us acquaint you with all the advantages of these improved instruments. Consult your nearest Weston representative, or write Weston Electrical Instrument Corp., Newark 12, New Jersey.

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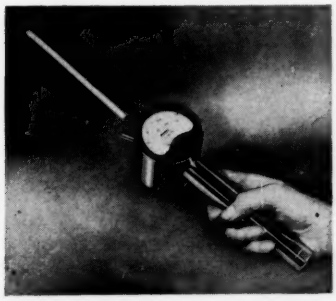
PANEL INSTRUMENTS

A DAYSTROM UNIT

For more information circle **81** on inquiry card.

would change cold junction temperature. Built-in thermometer near

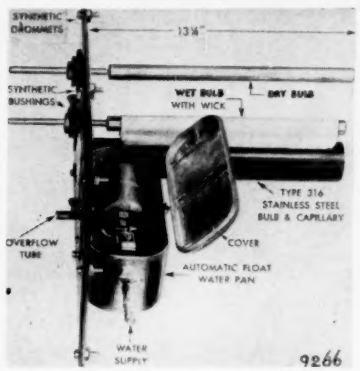


cold junction provides an accurate means of cold-junction calibration. Three ranges: "Model 321SL-IC" 50-650°F; "Model 321S-IC" 0-1600°F "Model 321S-CA" 0-2300°F; also C equivalents.—*Pacific Transducer Corp., 11836 W. Pico Blvd., Los Angeles, 64, Calif.*

For more information circle **223** on inquiry card.

CORROSION-RESISTANT HYGROMETRIC SYSTEM

New wet- and dry-bulb primary elements for measurement and control of temperature and humidity mini-



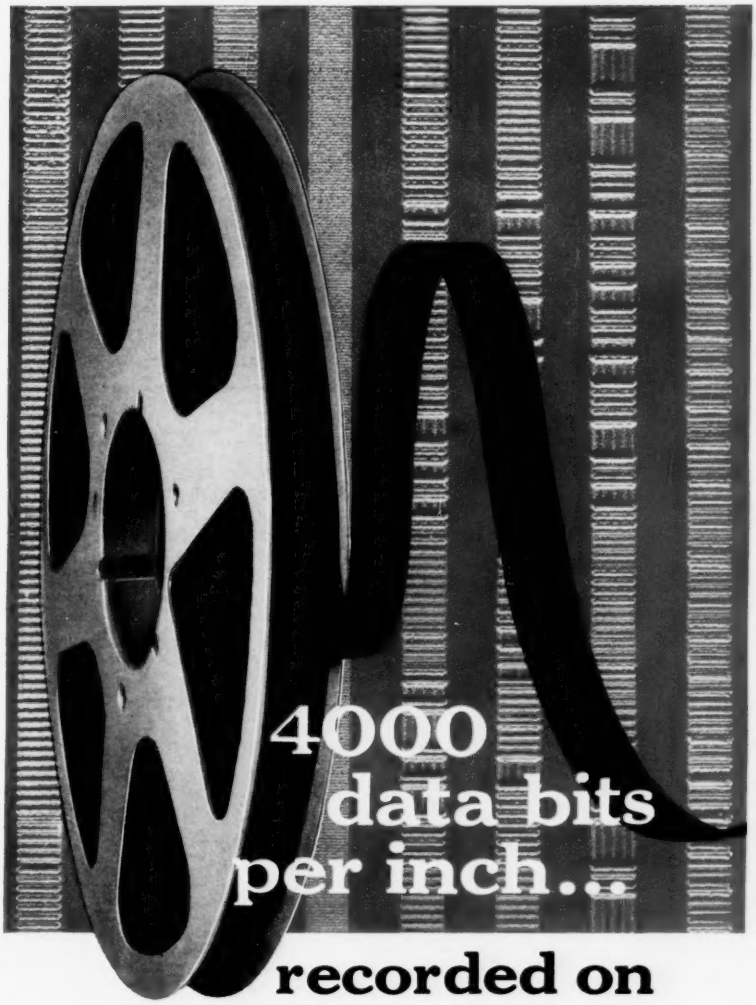
mize corrosion and electrolytic damage. System is designed for smokehouses and other uses where corrosive smoke or gases, plus galvanic action of wet-bulb water, can cause leaks to develop in wet bulb. Psychrometer insulation consists of rubber grommets in panel mounting holes, a length of hose in water supply line, and Bakelite bushings in bulb-fitting assemblies.—*Powers Regulator Co., 3434 Oakton St., Skokie, Ill.*

For more information circle **224** on inquiry card.

PROCESS HYGROMETER

New "Panel Mounted Electrolytic Hygrometer" continuously measures water concentrations in vapor samples with a 5% accuracy in the

Microphotograph of pulse recording on Soundcraft Instrumentation Tape



recorded on

SOUNDCRAFT type "A" INSTRUMENTATION TAPE

and played back without error!

In the new Rocketdyne IDIOT* II computer system, 4000 data bits (over 500 bits of information per channel, per linear inch) have been stored in an inch of Soundcraft Type "A" Instrumentation Tape... double the amount of information that has been stored in equivalent lengths of competitive tapes! What made the difference? Soundcraft Type "A" Tape ... the only tape engineered specifically for pulse recording. Its special RCCH oxide formulation provides an extremely hard surface with high thermal softening point – prevents imbedding of foreign particles. The formulation is uniformly applied to the durable Mylar† base by patented Uni-level process; then Micropolished to remove surface irregularities. These exclusive design features assure you of error-free pulse recording with Soundcraft Type "A" Instrumentation Tape. Write for Soundcraft Type "A" Instrumentation Tape Brochure.

*Rocketdyne Instrumentation Digital On-Line Transcriber. †Dupont T. M.

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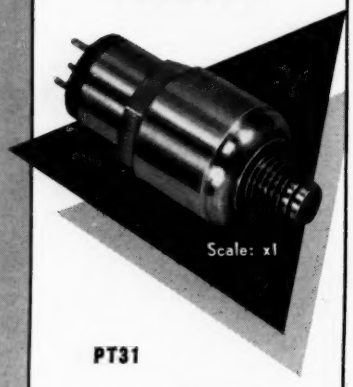
For more information circle **82** on inquiry card.

Dynisco

PRESSURE PICKUPS



PT31

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HIGHLIGHTS

MINIATURE SIZE

SMALL FLUSH-MOUNTED DIAPHRAGM

SIMPLE MOUNTING

½% ACCURACY

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TEMP. COMPENSATED

HIGH FREQUENCY

A.C. OR D.C.

PRESSURE RANGES: 0-300 to 0-7000 psi

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DYNAMIC INSTRUMENT CO.

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For more information circle **83** on inquiry card.

NEW INSTRUMENTS

difficult 0-1000 ppm range in temperatures up to 100°C; enables monitoring process streams, controlling corrosion, etc.; embodies an alarm system that can be set for any point in instrument's range; can operate a standard potentiometric recorder or recorder-controller (10 or 50 mv).—*Beckman Instruments Inc., Process Instruments Div., 2500 Fullerton Rd. Fullerton, Calif.*

For more information circle **225** on inquiry card.

FORCE, DISPLACEMENT, VIBRATION

20-LB. TENSION METER

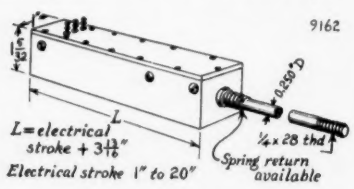
New light-weight Tension Meter has a range of 1 to 20 lbs, with great resolution at low tension end; features unique lever-inserting mechanism whereby two outer rollers are lowered or raised simultaneously; controlling lever is at side away from moving material, thus protecting operator's hands, and moving material is kept away from observer at all times. Rollers are tapered, thus widening opening where material to be tested is placed, while guiding material into test position. Wide flanges at

bottom of the low-inertia rollers hold material securely in place while tension is read as material travels at production speed.—*Transitron, Inc., Harvard, Mass.*

For more information circle **226** on inquiry card.

DISPLACEMENT PICKUP

New "Rectilinear Potentiometer" features independent linearity to 0.1%; one or two resistors (wire

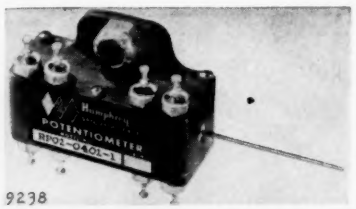


wound to user's requirements); precious-metal brushes and contact elements; housing of aluminum, gold anodized to AN-QQ-A696a; all plastic treated with fungicide varnish; taps can be made on windings.—*Precision Line Inc., Maynard, Mass.*

For more information circle **227** on inquiry card.

DISPLACEMENT PICKUP

New "Model RP02-0401-1 Rectilinear Potentiometer" has 0.75" mechanical travel; is suitable for both

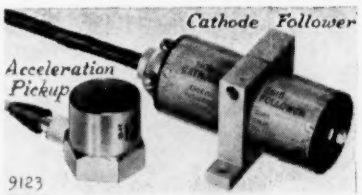


dc and ac; features precision cast case, glass seal terminals, stainless steel pushrod; weighs 1 oz and is 1.40" long. Resistance of both elements is 1000 ohms ±5%; linearity 0.75%; power dissipation of each element ½ watt; both elements center-tapped.—*Humphrey Inc., 2805 Canon St., San Diego 6, Calif.*

For more information circle **228** on inquiry card.

VIBRATION TEST SYSTEM

New "Model 2242 Accelerometer," "Model 2615 Cathode Follower" and "Type 3090 Connecting Cable" have



been designed to operate in ambient temperatures to 500°F without cooling or correction. Through use of newly developed Piezite II element, "Model 2242" pickup provides a mini-

MISSILE SYSTEMS ELECTRONICS

Activities at Lockheed Missile Systems' Research Laboratory in Palo Alto cover virtually every field of electronics related to missile systems. Inquiries are invited from those who desire to perform research and development of a most advanced nature. Please address the Research and Development Staff, Sunnyvale 1, California.

Here staff members discuss a laboratory model of an airborne component of a guidance system. Left to right: Dr. R. J. Burke, telemetering; E. A. Blasi, antennas; K. T. Larkin, radar and command guidance; Dr. S. B. Batdorf, electronic division head; Dr. H. H. Leifer, solid state; S. Janken, product engineering.

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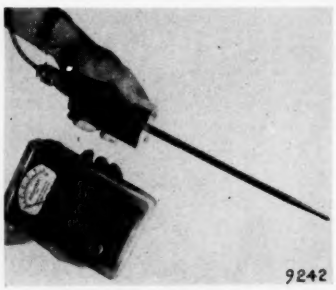
For more information circle **84** on inquiry card.

mum sensitivity of 8 mv per *G* for high signal-to-noise ratio even at low *G* levels. Response is down only 3% at 500° F. Its high natural frequency of 25 kc provides freedom from spurious resonant signals. Wide range: 0.25 *G* to 1000 *G*. Weight 1 oz. Cathode Follower and new all Teflon noise-treated cable can be used in 500°F ambients close to pickup and thus avoid loss of signal caused by long cables. Electronic parts of cathode follower are hermetically sealed in an inner housing which is vibration isolated from outer case, providing a low-noise system. Cathode follower gain is 0.94.—*Endevco Corp., 161 E. California St., Pasadena, Calif.*

For more information circle **229** on inquiry card.

VIBRATION TESTER

New portable (24 oz) self-powered "Model 305 Portable Vibration Amplitude Meter" is available in simplified



design so that inexperienced persons can use it.—*International Research & Development Corp., 797 Thomas Lane, Columbus, Ohio.*

For more information circle **230** on inquiry card.

SOUND AND VIBRATION RECORDER

New "SL-2b Dynamic High Speed Sound Level Recorder" has been improved with special emphasis to sound,

noise, and vibration measurements. Design features include: adjustable writing speed by a unique electronic

STROMBERG-CARLSON
Special-Purpose
TELEPHONE HANDSET

You can mount this special-purpose hang-up telephone almost anywhere: on desk, wall or piece of equipment. The handset shown is only one of many standard and special-application types you may order. The right-angle bracket provides 6 different mounting positions.

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You can get hookswitches with any spring combination you need. Illustrated are two of many possible arrangements.

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For more information circle **85** on inquiry card.

feedback system; push-button selection of chart speed; scale functions in linear, decibel, or loudness (phon) available. With a simple setup as illustrated, the most complicated acoustical measurements can be recorded rapidly and accurately.—*Sound Apparatus Co., Stirling, N. J.*

For more information circle **231** on inquiry card.

FLOW

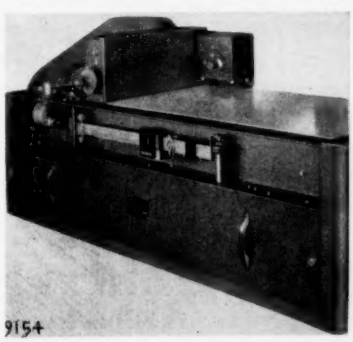
BLENDING CONTROL

New "Blendtrol" can be used to accurately maintain flow-rates in closed-loop systems or to blend and proportion in open-loop systems. It can be located several thousand feet from controlled process. In a typical proportioning application it receives from a flow-rate meter an electric signal proportional to flow-rate of major component; desired percentage of additive is set in on ratio dial; and this ratio is maintained through a "Shaftrol" or "Valvetrol." "Blendtrol" is adaptable to existing proportioning systems since most flowmeters can be modified to produce required control signal and "Valvetrol" can be installed on stems of valves in service. —*The Jordan Co., Inc.*, 3235 *W. Hampton Ave., Milwaukee* 9, *Wis.*

For more information circle **232** on inquiry card.

GRAVIMETRIC FEEDER

New "Model 37-20 Hi-Weigh" belt-type dry-material feeder, 3000 lb/min capacity, features: accuracy of 1% by weight; 100:1 variable speed drive giving exceptionally wide range of



MODELS PL80
AND PM80

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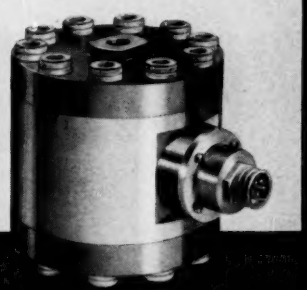
Pressure
Transducers
FOR
flow measurement



AT

Rocket Engine Stands
Hydraulic System Tests
Nuclear Reactors

the flow of liquids and gases is being measured by connecting Model PL80 and Model PM80 pressure transducers across an orifice.

Ranges
±1 to ±3000 psid and 0-1 to 0-3000 psid

Line Pressure Rating
5000 psig

Pressure Media
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Transduction
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For more information circle **86** on inquiry card.

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Data-Readout Counter

Provides 100,000 Distinct Circuit Arrangements

Electrically actuated data readout counter with electric reset. Form B-1538 for 110V AC/DC.

FUNCTIONS

Analog to Digital Conversion
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Predetermining
Repeat Predetermining
Sequential Programming

Veeder-Root's new series of Data Readout Counters combines visual indication with electrical readout for remote indication, recording, and controlling applications. *Electrically* or *mechanically* driven and provided with *manual* or *electric* reset, these counters present a positive display of accumulated totals and automatically create specific control circuit contact closures for each number visually displayed. Each instrument, with its five figure capacity, provides 100,000 distinct circuit arrangements which lend themselves to the most exacting control and transmission requirements. The counters are compatible with standard data processing equipment and offer a wide variety of applications in the industrial control and data processing fields.

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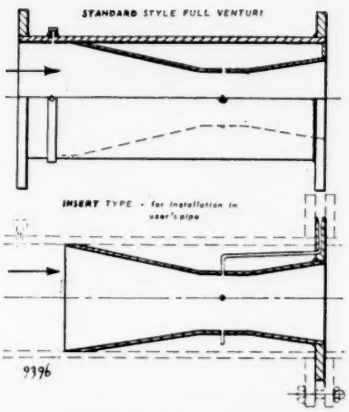
For more information circle **67** on inquiry card.

feed rates; rapid rate setting; "Sens-a-gram" instantaneous automatic compensator for variations in density of material; belt-cleaner and belt scraper preventing build-up of adhesive material on inside or outside of belt.—*Omega Machine Co.*, 345 *Harris Ave., Providence* 1, *R. I.*

For more information circle **233** on inquiry card.

VENTURI TUBES

New fabricated Venturi tubes are of low-pressure-loss design, with recovery cone angle of about 14°, short upstream straight run of pipe. Standard style has piezometer belts, is available with flanges as shown, with plain ends for Dresser or similar coupling, or with ends beveled for welding. Insert type has full piezometer ring for throat taps (upstream connection furnished by user). Both

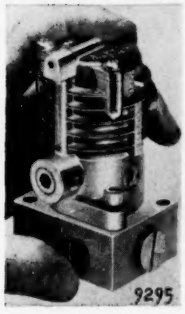


are available in 10" to 72" sizes and larger; usually with carbon steel outer casings and flanges, stainless steel inlet cone, throat and recovery cone. —*Vector Mfg. Co., Inc., Jenkintown, Penna.*

For more information circle **234** on inquiry card.

VALVES, ACTUATORS

4-WAY VALVE

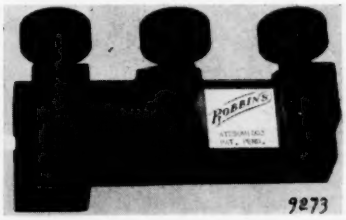


New "Bantam" miniaturized pilot-operated 4-way valve, said to be ideal for control of small double-acting cylinders and similar devices, is of unique single-solenoid design, with only 3 working parts. Four-way action is achieved with a single solenoid pilot and a pressure-balanced shuttle in valve body. Solenoid pilot, with coils for ac or dc, any voltage, is interchangeable with standard "Speed King" pilots and is built to JIC Standards. Manual override and integral junction box are optional features. Usable with pressures from 15 to 140 psi. All ports tapped ¼" NPT.—*Valvair Corp.*, 454 *Morgan Ave., Akron* 11, *Ohio.*

For more information circle **235** on inquiry card.

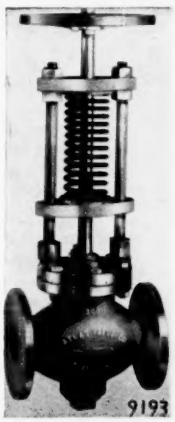
3-VALVE 5-PORT MANIFOLD

New aluminum three-valve manifold, with five ports, for use in air distribution boxes, operates from high vacuum to 3500 psi with finger-tip control at all pressures. Among features: any or all valves can be completely overhauled without disturbing the plumbing—valves being maker's standard valves which use plastic seats and "O" rings.—*Robbins Aviation*, 1735 *W. Florence Ave., Los Angeles* 47, *Calif.*



For more information circle **236** on inquiry card.

SPRING-LOADED RELIEF & BACK PRESSURE VALVE



New "No. 1605" spring loaded relief and back pressure valve functions on both condensing and non-condensing systems; is available in sizes 2½" to 6", with adjustment ranges varying from 5 to 35 psi. Bronze, steel or iron body; large discharge capacity and adjustable opening and closing pressures. Valve can be opened manually and, by turning handwheel until spring is no longer under compression, disc can be lifted from seat.—*Atlas Valve Co.*, 280 *South St., Newark* 5, *N. J.*

For more information circle **237** on inquiry card.

LIBRASCOPE
SHAFT POSITION-TO-DIGITAL
CONVERTERS
Equipped with ANTI-AMBIGUITY DOUBLE BRUSH PICKOFFS

Useful in a wide variety of applications, including digital aircraft and missile controls, machine tool controls, digital readout from strip chart recorders, and as the modulator and de-modulator in pulse-code modulated radio links.

GRAY CODE MODEL – Capacity of 8 binary digits (single brush pickoff).
BINARY MODEL – Capacity of 7 to 19 binary digits.
BINARY CODED DECIMAL MODEL Capacity range from 0-1999 to 0-35,999.

Units for special codes or capacities are built to meet specific requirements.

SHOCK ENDURANCE.....20g
TEMPERATURE RANGE..–50° to 83°C min.
CODE DISCS.....Rhodium plated phenolic
PICKOFFS.....Multiple wire brush. Two pickoffs/channel
ROTATION.....Continuous, either direction.

RUGGED—NON-MAGNETIC—LONG LIFE
MAY BE READ WHILE IN MOTION

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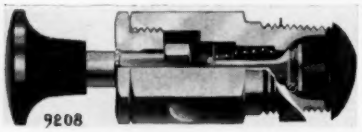
NEW INSTRUMENTS

VACUUM-BREAK VALVES

New "Model P-646" valves serve dual function of breaking vacuum automatically in draining and bleed-



ing air displaced in filling. Normally, valve seals dead tight to prevent loss of system pressure. When fluid is being withdrawn from system or temperature drops, valve opens automatically to break vacuum and permit free flow. A manual over-ride permits holding valve open to release entrapped air when system is being filled. Available in ½" and ¾" pipe sizes.—*Circle Seal Products Co., Inc.*, 2181 *East Foothill Blvd., Pasadena, Calif.*

For more information circle **238** on inquiry card.

VALVE OPERATOR BRACKET

New standard bracket and linkage arrangement for butterfly valves, greatly simplifies their hook-up with automatic control operators; offers advantages in operation and maintenance; reduces power requirements in

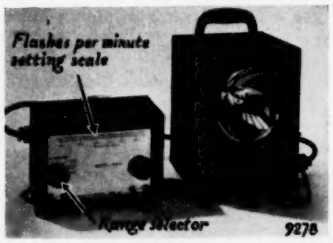
close control applications. An almost friction-free connection is provided between operator stem and valve shaft with no sloppy fits. Standard for butterfly valves up to 48" pipe size, in accordance with required torque.—*W. S. Rockwell Co.*, 200 *Eliot St., Fairfield, Conn.*

For more information circle **239** on inquiry card.

TIME, SEQUENCE

PRECISION STROBOSCOPES

New "Series 162 Stroboscopes," for speed measurement and motion studies in production-line and lab testing application, come in two units for maximal versatility. This allows interchanging control heads, or operating multiple lamps synchronously from a single control head. Two standard control heads optionally available: "162-G" (illus) wide-range



continuously-variable type with accuracy better than 1% and stability of better than 0.5%; (2) "162-P" limited range high-precision type with accuracy and stability of better than 0.1%.—*Slaughter Co., Piqua, Ohio.*

For more information circle **240** on inquiry card.

ELECTRIC STOP CLOCK-TIMER

New "Type 691 Time Totalizer," featuring instantaneous electrical reset (0.1 sec) and accuracy of 0.02%, is offered in a dust-tight commercial model and a hermetically-sealed shock-resistant military version; is available for either local or remote reset. For local reset, a pushbutton is provided on bezel. On sealed timer,

NEED TWO PRESSURES ON A SINGLE DIAL?

DIFFERENTIAL GAUGES

Designed to indicate the differential between two independent pressure sources with a single pointer.

Weksler Type 911R.

DUPLEX GAUGES

Designed for use where two related pressures are desired to be indicated on the same dial.

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Equipment...material...metallic or non-metallic...flat, curved... revolving or stationary—you can read every surface temperature accurately in less than 3 seconds!

Compact, complete in precision design, this rugged instrument assures highest standards of speed, accuracy and dependability.

Alnor Portable Pyrocons come in scale ranges to 2000° F., with thermocouples for every application. You'll find full details on the Pyrocon exactly suited to your operations in Bulletin 4257. Send for your copy now. Write: Illinois Testing Laboratories, Inc., Room 518, 420 N. LaSalle St., Chicago 10, Ill.

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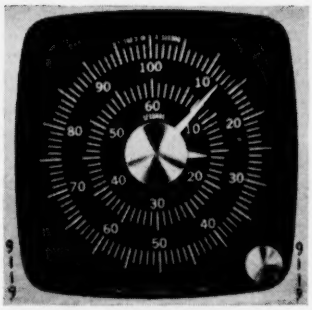
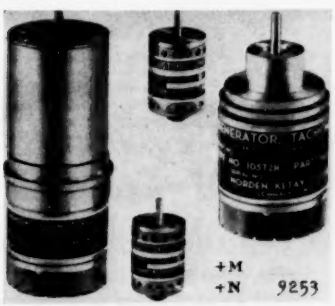


pushbutton actuates reset solenoid through a bellows. Load switches rated 5 amp @ 250 vac resistive, operated from cams on either fast or slow pointer shafts, can be supplied. Number of pulses per second or minute, and duration of pulses, are factory set. With switches on both fast and slow pointer shafts (wired in series) "691" can be used as a precise time delay or interval timer.—*Cramer Controls Corp., Centerbrook, Conn.*

For more information circle **241** on inquiry card.

MOTOR TACHOMETERS AND TACHOMETER GENERATORS

New line of motor tachometers and tachometer generators, for use in high-accuracy computers and servo



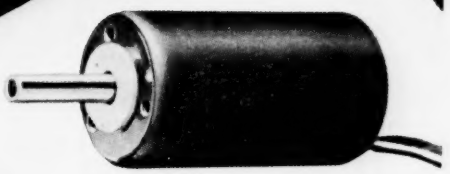
systems, feature: 0.12% linearity from 0 to 4000 rpm; temperature compensation to 0.3% over operating temperature range of −55°C to 80°C; output voltage pretrimmed to 0.2%. —*Norden-Ketay Corp., Commerce Road, Stamford, Conn.*

For more information circle **242** on inquiry card.

TRANSISTORIZED PLUG-IN COUNTING CIRCUITS

New subminiature transistorized plug-in counting circuits, said to effect "substantial savings in space and material requirements," are available in two basic types: "P Series" plug-in and "C Series" subminiature cartridge. Plug-in package fits standard 7-pin miniature socket and can be conveniently retained with a standard tube shield. Cartridge, a rectangular flat configuration for permanent installations, features high space den-

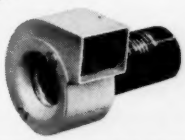
HEART of your miniaturization program



the EAD 1" MOTOR

Here is EAD's outstanding contribution to the miniaturization program . . . a one-inch diameter, 400 cycle precision motor, engineered for long life and high efficiency. Where minimum size and weight are essential, use this versatile unit. Modifications include high ambient and high altitude versions as well as low voltage designs.

MINIATURE TUBE AXIAL BLOWERS
For efficient cooling and air change in small electronic equipment. Driven by EAD's 1" dia. motor. No brushes, no arcing, no interference.



SUBMINIATURE CENTRIFUGAL BLOWERS
For spot cooling. Moves 9 CFM at 1.35 S.P. Powered by EAD's 1" dia. motor.

MINIATURE RING MOUNTED FANS
For peak performance, compactness, dependability. Blade dia. small as 2" — air del. greater than many heavier blowers. Uses EAD's 1" dia. motor.

MINIATURE GEAR MOTORS
Servo, synchronous or induction units, primarily for 400 cycle and var. freq. operation. Gear ratios up to 10,000 to 1. Basic types use EAD's 1" dia. motor.

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For very pure sine wave voltage, high power output. Low distortion, light weight, permanent magnet fields. Frame sizes begin with 1" diameters.

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For more information circle **91** on inquiry card.

sity stacking and miniature styling. Feature is embedment in a tough mica-filled thermosetting epoxy resin, whence maximum high and low temperature performance, as well as virtually imperviousness to shock, moisture, vibration, etc. Among types: (1) Binary Counters for use as binary or as a flip-flop, of "non-saturating" design assuring reliable operation up to 175 kc. (2) Triggers to convert a wave shape into a fast-rising pulse. (3) Delay Multivibrators to provide delayed feedback or reset pulses to "M 6003" Binary Counter." (4) Dual Emitter Follower Amplifiers to provide usable counter output without loading counters; one side of convenient independent dual construction provides an ac input terminal. All these circuits are available from stock.—*The Walkirt Company 141 W. Hazel St., Inglewood, Calif.*

For more information circle **243** on inquiry card.

SPEED TRANSMITTER

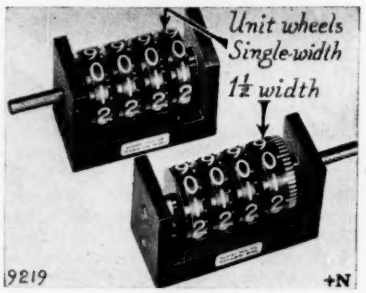
New "Type 16A Pneumatic Speed Transmitter" produces a pneumatic output linearly proportional to rotational speed; is particularly applicable to turbines, conveyor lines, compressors and mill equipment. Standard ranges 0-1600 rpm to 0-2400; with speed changers 0-320 to 0-5300. It operates on force balance principle with magnetic actuation of a standard pneumatic circuit. Its input shaft, coupled to rotating equipment, spins a multipole permanent magnet, rotating a magnetic field through a nonmagnetic disc close to magnet poles. This disc, with a force bar attached, tends to rotate in same direction as

magnet, positioning force bar in relation to an air nozzle. Resulting back pressure in the nozzle circuit, amplified by a relay, exerts force, through a free-floating ball piston which bears on force bar to balance torque produced on disc by rotating magnet. This 3-15 psig feedback pressure is received by an indicator, recorder or controller calibrated in units of speed. —*The Foxboro Co., Foxboro, Mass.*

For more information circle **244** on inquiry card.

INSTRUMENT COUNTERS

New "D Series" of counters applicable as read-out indicators comprises 28 different models, with uniform con-



figurations of case, wheels and components, whence an advantage to original-equipment manufacturer. One-piece nylon wheels with nylatron pinions permit higher speeds with less noise, less torque, and longer life than previously available; greatly reduced moment of inertia and total weight.—*Durant Mfg. Co., 1914 N. Buffum St., Milwaukee 1, Wis.*

For more information circle **245** on inquiry card.

MARSHALLTOWN

DIAPHRAGM GAUGE

For Accurate Pressure Measurement in Ounces or Inches of Water

Marshalltown Figure 83 is an extremely sensitive gauge that uses a carefully seasoned bronze diaphragm to accurately measure very low pressures. It is used extensively on many types of natural gas installations for checking low pressures.

Write for details and price. LOOK TO MARSHALLTOWN FOR ONE OF THE MOST COMPLETE LINES OF INDICATING PRESSURE GAUGES MADE!

Available in standard dials (reading in inches of water) 0-15" -0-30" -0-60" -0-100" -0-160" . . . also in ounce graduated dials from 15 ounces to 5 pounds. 2½", 3½" and 4½" dial sizes mounted in black enameled steel case.

MARSHALLTOWN MANUFACTURING CO.

MARSHALLTOWN 3, IOWA

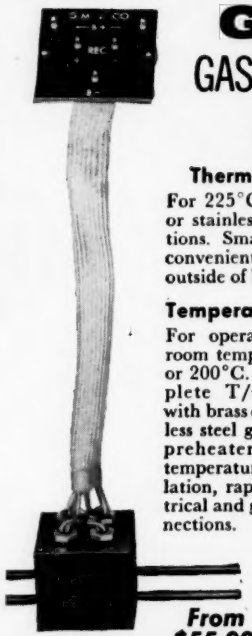
For more information circle **92** on inquiry card.

Fast! Accurate! Economical!

GOW-MAC

GAS CHROMATOGRAPHY

CELLS

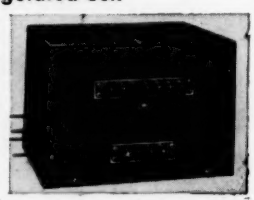


Thermal Conductivity Cell

For 225°C operation. Three models in brass or stainless steel to meet specialized applications. Small internal volume, fast response, convenient mounting, electrical connection outside of bath.

Temperature Regulated Cell

For operation at room temperature or 200°C. A complete T/C unit with brass or stainless steel gas flow, preheater, close temperature regulation, rapid electrical and gas connections.



Power Supply and Control Unit

gives five minute hook-up with complete circuitry for these T/C cells. Write Dept. IA for catalogs or recommendations.

From $55.00

GOW-MAC INSTRUMENT CO.
100 KINGS ROAD, MADISON, N. J.

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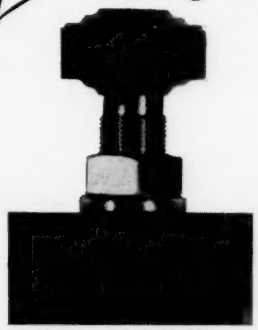
ROBBINS

Leakproof Metering Valves



- Hi Vacuum to 6000 PSI.
- "O" Rings and Teflon or Nylon Seats are standard.
- Over-torquing cannot damage seat or needle as buffer plate and metering pin act as a forming die.
- Impossible to score needle or seat.
- Lifetime Valve—can be completely overhauled in a matter of minutes without disturbing plumbing or mounting.
- The most economical valve in the long run.

Write for further details.

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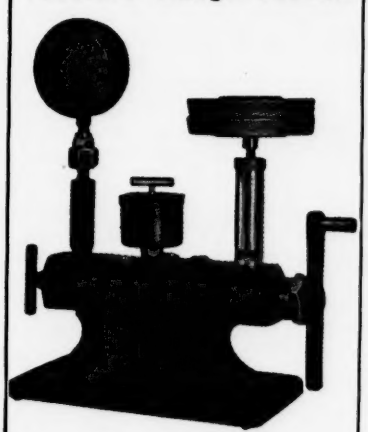
AMTHOR Dead Weight Pressure Gauge TESTER



Designed for simplicity and compactness, this tester incorporates the newest refinements and improvements and is praised by users in all industries for long lasting troublefree service. Made in ranges up to 10,000 P.S.I. We guarantee accuracy of 1/10 of 1%. Supplied in metal carrying case with adapters and tools. Weighs in special metal container for storing.

Ask for literature also on Tensile Testers. Indicating and Recording Tachometers and thickness Gauges.

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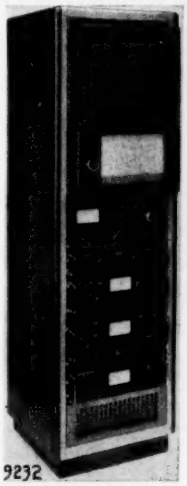
Testing Instrument Co., Inc.
45 Van Sinderen Ave., Brooklyn, N. Y.

For more information circle **95** on inquiry card.

COMPUTING, DATA PROCESSING

AUTOMATIC CHART READER

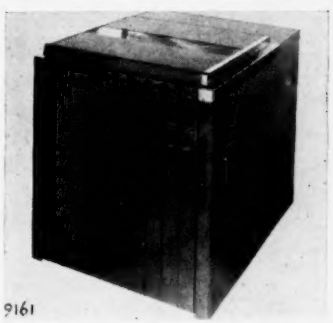


New "Model 3800" moves a chart at a uniform rate, senses position of inked trace on chart, and produces an output proportional to ordinate value of trace. Output is presented in the form of varying voltage, shaft rotation, changing digital numbers, or as a pulse-width modulated carrier. Illustrated model is designed to read standard charts from null-balance recorders; changes to adapt it for other charts and other functions of trace ordinate can be made. Reading accuracy is 0.1% of full-scale.—*The Geotechnical Corporation*, 3712 *Haggar Drive, Dallas 9, Texas.*

For more information circle **246** on inquiry card.

TAPE-TYPE MEMORY

New "Model 3219 Digital Magnetic Tape Multiple Bin Handler" stores over 160 million bits; can be employed



for sequential sorting or as a high-capacity random-access memory; comprises ten separate identical units or bins each with a storage capacity of over 8 million bits, a bin normally containing 500 ft of 1" wide mag tape for 14 channel recording with 200 ppi density. Each bin is equipped with its own record-playback head which can be relay switched to a common output. Among important uses is electronic sorting of digital data: employing digit-by-digit method with a simple counter and matrix, decimal sorting rates up to 100 information blocks per second are achieved.—*Potter Instrument Co., Inc.*, 115 *Cutter Mill Rd., Great Neck, N. Y.*

For more information circle **247** on inquiry card.

precision

PRESSURE REGULATORS

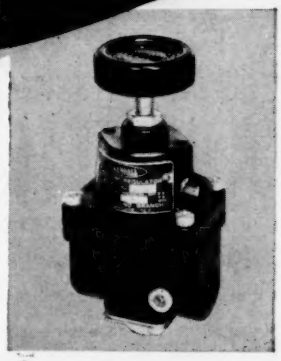
14 models to meet almost all industrial needs

Send for catalog

Now available from the Stratos Industrial Products Branch are two complementary lines of pneumatic pressure regulating valves.

The pilot-operated GOVERNAIRE: very high flows are regulated by small signals in these self-contained, pilot operated models. Up to 250 psi supply pressure, pipe sizes from ¼ to ¾ NPT.

Drift-free, lever set model 3500



The direct acting KENDALL: also available in a wide flow range, these force-balanced types are designed for operation at up to 250 psi supply pressure. Pipe sizes from ¼ to ⅜ NPT.

STRATOS
INDUSTRIAL PRODUCTS BRANCH
A division of Fairchild Engine and Airplane Corp.
Route 109, West Babylon, N. Y.

For more information circle **96** on inquiry card.

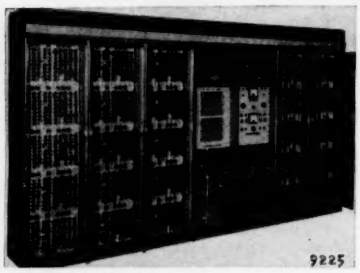
HIGH-SPEED AUTOMATIC PLOTTER

New "Electroplotter S" accepts information from punched paper tape, punched cards or magnetic tape. Its simplest output is a two-dimensional *X-Y* point-to-point plot. Its more complex displays include (1) presentation of digital information at demandable positions over plotting area; (2) plotting discrete points at any position, "flagged" by a line of digital and symbolic information; (3) rotation of entire printing mechanism forming plotted point; or any simultaneous combination of these three.—*Benson-Lehner Corp.*, 11930 *W. Olympic Blvd., Los Angeles* 64, *Calif.*

For more information circle **248** on inquiry card.

COMPUTER CONTROL LINK

New "Addaverter" is a high-speed multi-channel computer control link which interconnects digital and analog systems for computer-controlled processes. It functions as a translating means whereby data in both digital and analog forms are made compatible so that the two types of systems can be effectively interconnected. It can be slaved either to the computing program of a digital computer (such as Sperry-Rand 1103A or IBM 704) or to any standard-voltage-range analog device. It contains an internal memory that enables it to receive a multiplicity of commands or data from the digital computer or, conversely, to collect a set of translated analog events prior to transfer between the two systems. If desired,



by pre-programmed commands, new sets of data or stimuli can be presented by the digital computer to the analog system or, conversely, sets of data collected from the analog system can be presented to the digital computer. System can accurately handle information having a dynamic range of over 100,000 to 1 in microseconds. Its accuracy is 0.1% of the actual voltage or number or 1 mv (whichever is greater). Its conversion equipment, control equipment, and terminal equipment comprise

THE ENGINEERED

ARIDIFIER

SUPER-CLEANS, SUPER-DRIES COMPRESSED AIR AND GAS

Engineered to your compressed air or gas line, the ARIDIFIER stops 92% of dirt, oil, scale and water in the air stream. Multi-bladed rotors whirling in opposite directions pick off water and sludge, dash them against vertical walls, from where they drop by gravity into a drain trap. Free of these impurities, air or gas comes out of the ARIDIFIER super-cleaned, and super-dried. Air tools, spray guns, hoists, sand blasters, etc. perform as they should, and last far longer.

Learn how the engineered-to-your-line ARIDIFIER can solve your problem and save you trouble and money. Write for the Aridifier catalog.

Exploded view showing ARIDIFIER operation. Capacities, 7 to 17,000 C.F.M.

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For more information circle **97** on inquiry card.

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Volume I

(Circuits 1-100)

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COVERS

Power Supply Circuits	Test Instrument Circuits
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$2.00 postpaid

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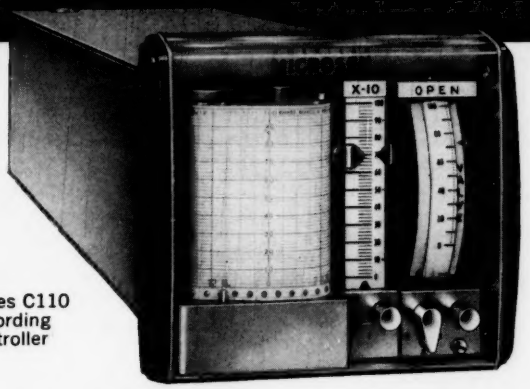
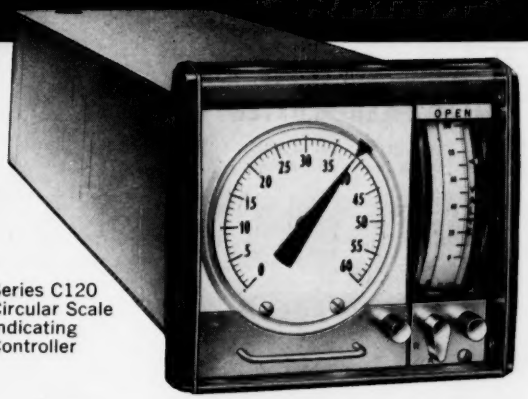
NEW TRANSISTORIZED ELECTRONIC CONTROLLERS
Interchangeable for complete versatility



Series C110
Recording
Controller



Series C120
Circular Scale
Indicating
Controller

The new 'American-Microsen' Series C100 Electronic Controllers can be interchanged at the panelboard in seconds. A recording controller to an indicating type . . . a proportional-action controller to proportional-plus-reset . . . slow reset to fast reset – any of these replacements is quickly made by pulling one unit out and plugging in the other.

The controller settings of the 'American-Microsen' System are all calibrated and repeatable. When a controller station is replaced, the proportional, reset and rate settings can be made in advance so the process is on control the instant the changeover is completed. No playing around to tune in the control.

When the process is on manual control during a replacement operation, the controller station stays in balance with the actual valve position. Thus the process can be changed back to automatic control without "bumping" or upset. A unique feature of the 'American-Microsen' System eliminates any "balance" or "seal" position between manual and automatic.

These are but a few of the many functional advantages of the new 'American-Microsen' Electronic Control System. Join the many satisfied users of this new approach to process control. Make certain you have the better control and simplified servicing so essential to higher product quality and greater operating economy. Arrange for a meeting with one of our sales engineers to determine the best equipment for your service. *Write for Bulletin RC100.*

Controller Performs These Functions

Measures input signal from transmitter and records or indicates in terms of the measured variable — pressure, temperature, flow, etc. (The Series C110 records on a 3-inch wide strip chart, the Series C120 indicates on a 4-inch diameter scale.)

Provides means of setting the desired value of the measured variable (set point) and compares actual value with desired value.

Transmits control signal, incorporating proportional, reset, and/or rate actions to operate final control element.

Provides means to operate control element manually with simple switch and manual knob.

Ultra-Modern Features Provided

All functions of recording (or indication), controlling (proportional, reset, and/or rate), and manual valve operation *in a single housing.*

Transistorized controller station for ultimate reliability and long service life.

Printed circuitry and miniaturized components for space-saving simplicity.

Plug-in units for complete interchangeability and ease of maintenance.

Ratio, cascade, and other similar control arrangements, using standard instruments.

Direct bumpless transfer from manual to automatic control with no intermediate position.

DC signals of 1.0 to 5.0 milliamperes for instantaneous distance transmission up to 30 miles.

Controllers are compatible with any unit of other manufacture using the standard 1 to 5 milliampere DC signal.

MANNING, MAXWELL & MOORE, INC.

MAXWELL MANNING M&M & MOORE INC. TRADE MARK

INDUSTRIAL CONTROLS DIVISION • STRATFORD, CONNECTICUT

MAKERS OF 'AMERICAN-MICROSEN' ELECTRONIC INSTRUMENTS FOR MEASUREMENT, TRANSMISSION AND CONTROL

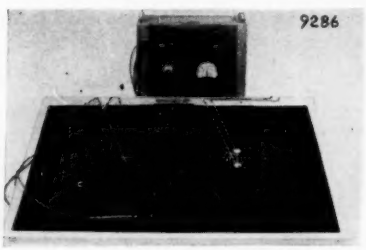
For more information circle **98** on inquiry card.

maker's standard plug-in units, using ruggedized "Five Star" computer tubes throughout. Depending on number of conversion channels required, system occupies from four to eight standard 7-ft metal cabinets.—*Epsco, Inc., 588 Commonwealth Ave., Boston 15, Mass.*

For more information circle **249** on inquiry card.

ANALOG FIELD PLOTTER

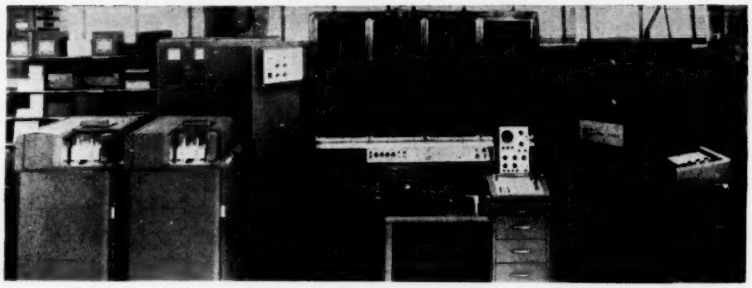
Newly redesigned highly-sensitive dry-paper type field plotter is com-



pletely packaged in a single unit with all accessories contained in compartment built in top. Solves mathematical functions, including orthogonal plotting, electrostatic and electromagnetic fields, gas and liquid flow and heat transfer problems.—*Sunshine Scientific Instrument, 1810 Grant Ave., Philadelphia 15, Pa.*

For more information circle **250** on inquiry card.

SCIENTIFIC AND BUSINESS COMPUTER

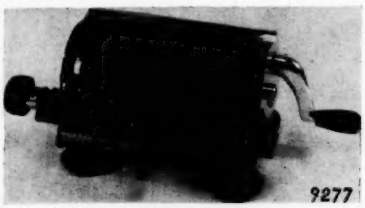


New "Readix Dual Computer" can handle research and development problems and also process business data for small and intermediate firms and organizations; is said to be "the lowest-priced completely Decimal Computer, with built-in Floating Point, and Magnetic Tape Console Units, on the market."—*J. B. Rea Co., 1723 Cloverfield Blvd., Santa Monica, Calif.*

For more information circle **251** on inquiry card.

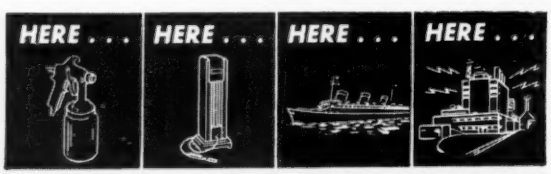
DESK CALCULATOR

Newly available on US market, light-weight (3 lb) low-priced (under $75) "Model 101 Produx-Multator" adds, subtracts, multiplies and divides. Capacity: 10 × 5 × 10 to 15 digits. Among many features: back transfer, setting levers in 3 colors, cancellation knob, decimal-point indicators, suction-cup feet to hold machine firmly in place.—*Silver Bells*



Limited, 600 16th St., Oakland, Calif.

For more information circle **252** on inquiry card.



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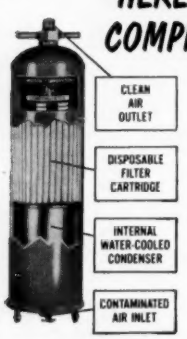

From steel companies to steamships . . . from paint spray equipment to power plants . . . wherever POSITIVE PROTECTION for pneumatic instruments and controls is required, Hankison Condensifilters are specified.

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- Dirt — Scale — Rust

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HC-12

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DO YOU NEED THE ADVANTAGES OF A POTENTIOMETER TYPE TRANSDUCER?

Servonic "Model H" pressure transducers retain system simplicity and high electrical output, but they offer these operational extras . . .

RUGGED	Vibration resistant — plus or minus 20 g's. — 100 to 2000 cps.
STAINLESS STEEL	Corrosion resistant — two corrosive fluids. — gauge and differential models.
LONG LIFE	Lubricated bearings and potentiometer. Sealed against the action of dust and humidity.
UNIQUE CONFIGURATION	Designed for "Stacking." Designed for easy access to electrical and fluid connectors.
OPERATIONAL RANGES	Temperature — minus 65°F. to plus 400°F. Pressure — 1000 to 10,000 psig. — 1000 to 10,000 psid.

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For more information circle **100** on inquiry card.

Attention: Readers and our Advertisers

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AUGUST • 1957

Will Preview the 12th Annual Instrument Society of America Conference & Exhibit

INSTRUMENTS & AUTOMATION subscribers, accustomed to I&A's top-flight news coverage, will find more of the same in the "New Products on Display" features of this special issue. Edited for really *busy* readers, reviews will describe each NEW product or development precisely, telling exactly what it is, what it does, and where it can be used.

This kind of concise show-news coverage also benefits **INSTRUMENTS & AUTOMATION advertisers:**

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- Non-exhibitors use the pre-show issues as their "exhibit-in-print," where they can display their products via advertising to this same interested audience, and to an additional 5,000 non-subscribers who will receive copies of this special issue AT THE SHOW.

For this issue, I&A's regular distribution will be supplemented by 5,000 extra distribution at the show, **at NO increase in space rates.**

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ELECTROMECHANICAL

INSTRUMENTATION CLUTCH

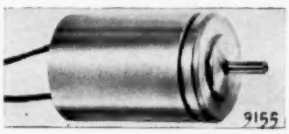
New "SF-100" electromagnetically-operated miniature clutch, for use on low-torque drive of instruments and

miniaturized control mechanisms, gives instantaneous positive engagement and release of loads up to 2 lb-in (static torque rating). No slip rings or brushes are required: flange-mounted field is connected through pigtail leads to a 28- or 90-vdc source. Torque is transmitted through rotor to armature which can be keyed to driving or driven member. Max power required is 6 w. Mounting requirements for flange-mounted unit are extremely simple.—*Warner Electric Brake & Clutch Co., Industrial Div., Beloit, Wis.*

For more information circle **253** on inquiry card.

400-DEG F SYNCHRO

New "Type 11-4133-01" size 11 torque-transmitter synchro has unprecedented —65°F to 400°F operat-



ing temperature range and 250-hour life at 400°F, owing to an unusual lubrication method and a special alloy for electrical connections. Accuracy 15 min; null voltage 175 mv; stator output 90 v and phase shift 6.5°.—*John Oster Mfg. Co., Avionic Div., Racine, Wis.*

For more information circle **254** on inquiry card.

125-deg C AC RELAY

New miniature ac relay for high temperature applications incorporates silicon rectifier assemblies which will withstand temperatures from —65°C to 125°C; operates on 115 v 60 to 400 cps; is available in 6-pdt or 4-pdt models with plug-in or solder-lug connections and standard mountings. Will withstand vibrations up to 1000 cps at 15 G and shock in excess of 50 G; meets or exceeds all requirements of MIL-R-5757-C, MIL-R-25018, and MIL-R-6106B; suitable for airborne circuits, including jet planes and missiles.—*Union Switch & Signal, Div. of Westinghouse Air Brake Co., Swissvale, Pa.*

For more information circle **255** on inquiry card.

DC-AC CHOPPERS

New dc-ac choppers designated as "Frequency Doublers" because they multiply 60-cps excitation frequency and their contacts generate a 120-cps square wave. (All previous choppers had identical input and output frequencies.) Available in 23 different models, single-pole and double-pole, for use on commercial 60-cps power (50-cps models also). Popular types usually delivered from stock. —*Stevens-Arnold Inc., 22 Elkins St., So. Boston, Mass.*

For more information circle **256** on inquiry card.

Who likes to keep a customer waiting? Not the men of Plummer & Kershaw at any rate. Unfortunately scheduling is easy but producing to the high quality standards that have made P & K respected, is another thing. Work done with skill and care is not work that can be produced quickly. As inevitable then as night follows day it is necessary to specify longer delivery dates—we feel sure you wouldn't want it otherwise.

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For more information circle **101** on inquiry card.

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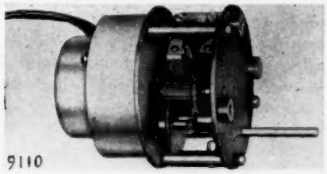
NEY'S SMALL PARTS PLAY A BIG PART IN PRECISION INSTRUMENTS

For more information circle **102** on inquiry card.

MOTOR-&-CLUTCH UNITS

New solenoid-operated clutch motors consist of maker's "Circle B" motor driving one of the inputs of

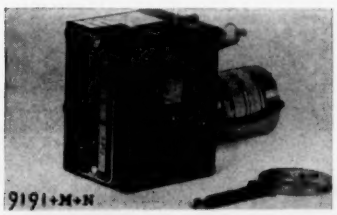


a differential and a solenoid-operated finger stopping or releasing the other input. Output of differential connects directly to output shaft, which is disconnected from motor gear train when not in use. Full running torque can, therefore, be used to start a load. Available clockwise or counter-clockwise, output speeds from 60 rpm to 1 rev per month. Output torque is limited to developed torque of motor. All motors and clutches rated for 115 v 60 cps. Other voltages and frequencies can be provided.—*Bristol Motor Div., Vocaline Co. of Am., Inc., Old Saybrook, Conn.*

For more information circle **257** on inquiry card.

MINIATURIZED SAMPLING SWITCH

New miniaturized version of maker's "Type A Sampling Switch" weighs 7 oz; measures 2-$\frac{1}{16}$" x 1-$\frac{13}{16}$"

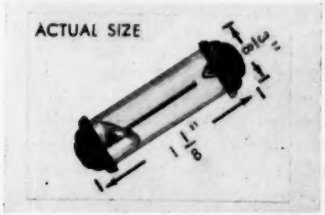


x 1-$\frac{11}{16}$". A filtered 27.5 vdc motor rotates switch at 2.5 rps providing a sampling rate of 150 samples per second.—*Applied Science Corp., P. O. Box* 44, *Princeton, N. J.*

For more information circle **258** on inquiry card.

MERCURY SWITCH

New low-cost hermetically-sealed mercury switch is of tilting type style designed to be installed in the



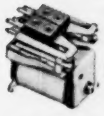
same manner as a cartridge fuse (spring clips or holders can also be used for mounting purposes). Weight 0.16 oz. Operation is noiseless and contact position is readily visible.

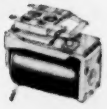
Potter & Brumfield *engineering is in this picture*

Which P&B relay would you specify to keep conversation going over a

MOBILE 2-WAY RADIO?

MB Series


TS Series


MC Series

When one of America's leading manufacturers of electrical and electronic equipment began the design of a lightweight 2-way car radio, they were faced with several specific requirements in selection of relays. They had to be compact, light in weight and engineered to withstand the shock and vibration of off-the-road service. P&B engineering solved the problem with a modification of the TS series multiple switching relay.

In this application the TS relay has a dual personality. It connects the power supply unit to *both* the transmitter and the receiver. Power supply is controlled through the relay to either unit by the operator.

This is just another example of how P&B engineering is daily adapting standard types of relays or designing completely new types to meet specific requirements of new products. P&B's unique 25 years of engineering experience in relay applications is a source of quick, correct answers to your relay problems. Write today for new compact catalog.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC, ELECTRICAL AND REFRIGERATION DISTRIBUTORS

ENGINEERING DATA

SERIES: TS. Miniature off-set springs telephone type.

CONTACTS: 5/64" dia. palladium (rated 3 amps.) ⅛" dia. pure silver (rated 5 amps.).

CONTACT ARRANGEMENTS: Up to 20 springs, maximum 10 in each stack, using any form combinations within max. limits.

VOLTAGE RANGE: DC: up to 220 V. AC: up to 230 V. (4 poles).

COIL RESISTANCE: 30,000 ohms. Shaded coil available for 60 cycle operation up to 230 V. using 4.7 VA nominal.

POWER REQUIRED: 100 mw. per movable arm.

TEMPERATURE RANGE: Stack insulation of XXX phenolic spacers: —55° C. to +85° C. Glass melamine spacers: —55° C. to +125° C.

TERMINALS: Pierced solder lug holes for 2 No. 16 hook-up wires. Also available: Push-on taper tab connectors.

ENCLOSURES: Dust cover or hermetically sealed enclosures: Round: With octal plug (Max. of 8 springs) Rectangular: With octal plug; 4 to 14 pierced solder lugs; header to fit 14-pin miniature relay socket; Multiple solder header 18 springs Max.

DIMENSIONS: (4 Form C) 1-19/32" L. x 1-1/16" W. x 1¼" H. (open) (4 Form C) 1¾" L. x 1-13/32" W. x 2-3/16" H. (Hermetically sealed) (6 Form C) 1-29/32" L. x 1-5/16" W. x 2-9/16" H. (Hermetically sealed).

The standard TS structure with a life of 100 million operations will soon be available.

Potter & Brumfield, inc. PRINCETON, INDIANA

Subsidiary of AMERICAN MACHINE & FOUNDRY COMPANY

Manufacturing Divisions also in Franklin, Ky. and Laconia, N. H.

See our catalog in Sweet's Product Design File.

For more information circle **103** on inquiry card.

Electrical ratings: sp-st 1.75 amp @115; 0.6 amp @230 v.—*The Mercoid Corp.*, 4201 *Belmont Ave., Chicago* 41, *Ill.*

For more information circle **259** on inquiry card.

CONDUIT CLAMP BRACKET

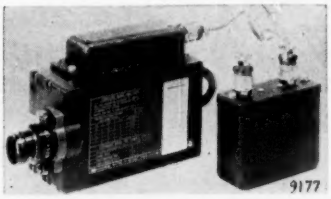
New bracket, to be attached to side of a cable trough section or fitting (for support of cable, conduit, or piping when crossing side of trough), can be used with all standard conduit clamps and is secured by a simple bolt-type connector. This new clamp simplifies combining a cable trough supporting system with other types of cable supports.—*T. J. Cope, Inc., Third & Walnut St., Collegeville, Pa.*

For more information circle **260** on inquiry card.

PHOTOGRAPHY

INSTRUMENTATION CAMERA

New "TN-9," with modifications and adaptions of standard GSAP Bell & Howell "N-9," is said to be "the most versatile camera available." Three basic designs: "TN-9" standard instrumentation design; "TN-9A" automatic exposure control design; and "TN-9B" pulse-operated interval design. Optional features include: automatic exposure control, strip or "streak," operation, conversion to slow speeds or to a single high speed, conversion for use under loads

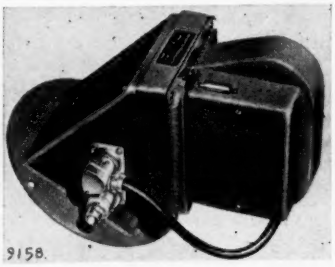


to 100 *G.*—*Traid Corp.*, 17136 *Ventura Blvd., Encino, Calif.*

For more information circle **261** on inquiry card.

COMPUTER READOUT CAMERA

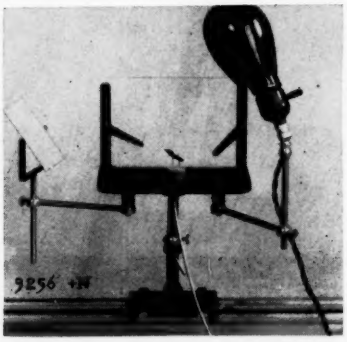
New "Beattie Varitron" for high-speed readout with computer and computing systems picks up computer readout directly from CRT presentation, eliminating time lag. Summations thus recorded on film require minimal storage space; provide an immediate record; can be enlarged later for detailed study. Among features: special field-flattening optics; precision micrometer lens focusing mount; automatic film run-out indicator. Capacity 100 ft of 35mm film automatically advanced. Exposures can be made at predetermined intervals or at random.—*Photographic Products Inc.*, 1000 *No. Olive St., Anaheim, Calif.*



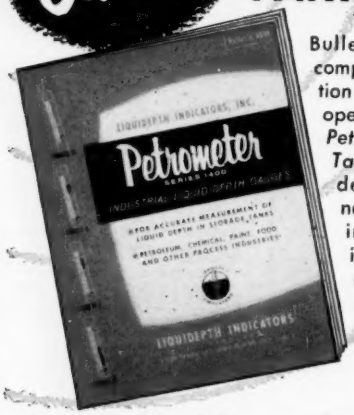
For more information circle **262** on inquiry card.

PHOTOGRAPHIC STAGE

New precision photographic stage, for use with "Meyer Universal Instrument Bench," has a horizontal



How to Choose THE RIGHT REMOTE READING TANK GAUGE



Bulletin 6004 presents comprehensive information on the selection and operation of the *New Petrometer Series 1400 Tank Gauges.* It also describes the many new design features incorporated in the indicators to provide quick, easy installation, trouble-free automatic operation and accurate indication.

Send for your free copy today!

Petrometer CORPORATION

43-22 TENTH ST., LONG ISLAND CITY 1, N. Y.

For more information circle **104** on inquiry card.

NEXT TIME YOU NEED

RELAYS

GET A "QUOTE" FROM

COMAR

Each year, more and more manufacturers are specifying "Comar" as their relay source. They've found that Comar has the facilities and know-how to produce good dependable relays at low cost. Next time you need relays, get a "quote" from Comar. You'll be glad you did.

Comar ELECTRIC COMPANY
3349 ADDISON ST., CHICAGO 18, ILLINOIS

RELAYS • SOLENOIDS • COILS • SWITCHES • HERMETIC SEALING

For more information circle **105** on inquiry card.

surface 4¾" by 8". Uprights at rear accommodate ground glass, opaque plates, etc. Beneath stage are mounted two swinging arms, in universal sockets. Flexible wire cable, and micrometer-type lead screw enable photographer to get precise focus required for ultra-closeup scientific photography.—*Universal Instrument Bench Div., O. K. Machine & Tool Corp., 551 East 179th St., New York 57, N. Y.*

For more information circle **263** on inquiry card.

PHOTOCOPY DUPLICATOR

New "Model 112" makes instant copies of book or magazine pages as well as single sheets; produces a

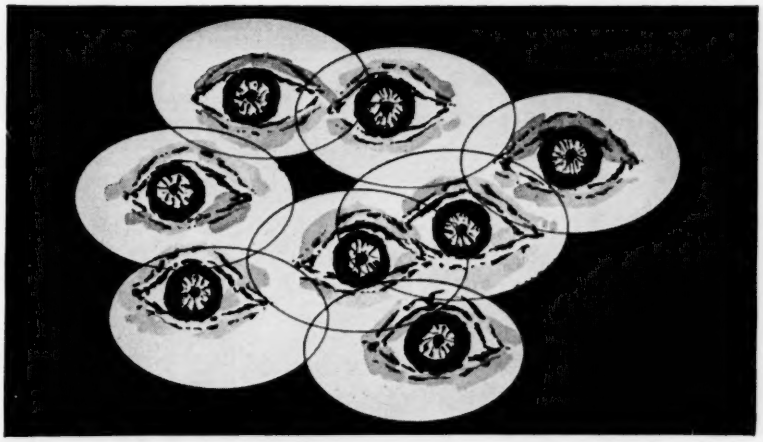
sharp black on white copy of any original material, including color pictures, and material printed on both sides of the page. Copies are produced on a non-wrinkling paper. For further flexibility, photocopying can be combined with offset duplicating: new unit accommodates an aluminum transfer offset plate which will produce several thousand copies. Also, new model uses slow negative paper. Its automatic timer can be set for sensitivity of negative paper and density of original.—*A. B. Dick Co., 5700 W. Touhy Ave., Chicago 31, Ill.*

For more information circle **264** on inquiry card.

LABORATORY, ANALYTICAL

DROP COUNTER

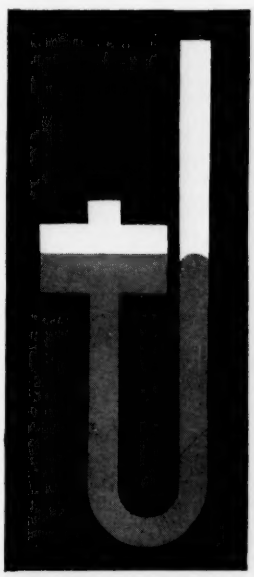
Newly available commercially: photoelectric drop counter developed by Instrument Section of National Institutes of Health. Accurate counting is achieved by an amplifier so sensitive that an extremely small reduction of light is sufficient to trigger photoelectric response. Falling drop itself acts as a lens, spreads a halo of diffused light, so that position of dropping tip need not be critical. No intense light source or lens system being needed, partial evaporation of slow-forming drops and changes in chemical structure of some solvents, caused by heat radiation, are avoided.



• • • for blind transmitters

Raised-Well Type Manometers

Raised-well type manometers permit zero to be located at any specified point on the scale; with pressure readings upscale, vacuum readings downscale; or in terms absolute. More details in Bulletin G-14.



Eye-witness verification of your non-indicating transmitters is simply, economically obtained with Meriam Manometers.

Manometers will enable your operators to check calibrations at all times . . . to tune control set points more precisely . . . to visually "read out" and log selected values more accurately . . . to continue operation during transmission interruptions.

There are Meriam Manometers especially constructed for outdoor exposure; for working pressures up to 2000 psig. They can bring otherwise unattainable accuracy *and reproducibility* to your plant instrumentation. Only a manometer gives *perfect* reproducibility . . . and reads out to whatever sensitivity you require. And, manometer accuracy is for keeps . . . never requires recalibration. Centralized instrumentation, today, requires the back-up of manometers . . . out where the measurement begins.

NEW

. . . complete and informative guide to manometer theory and practice as well as manometer models for plant, field and laboratory use. Just ask for Bulletin G-14. The Meriam Instrument Company, 10920 Madison Avenue, Cleveland 2, Ohio.

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For more information circle **106** on inquiry card.

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0.000,000,000,000,000,1 = 10^{-16} ampere

Rely on the CURTISS-WRIGHT

DYNAMIC CAPACITOR ELECTROMETER

(Model NA 100)

ELECTRONICS: Measurement of semiconductor parameters, low-level voltages, static charges, floating grid potentials, grid currents, and insulation resistance

INDUSTRY: Beta and gamma gauge control systems

PHYSICS and CHEMISTRY: Mass spectrometry, pH measurements

NUCLEONICS: Reactor control and radiation monitoring systems

BIOPHYSICS and MEDICINE: Measurement of stomach acidity, skin and cell potentials.

A current of 10^{-16} amp consists of a stream of only 625 electrons per second. No wonder it takes an extremely sensitive instrument to measure such traces of moving electrons.

The Curtiss-Wright Dynamic Capacitor Electrometer will detect even smaller currents, since one meter division represents 2 x 10^{-17} ampere, which is well above the noise level. Measurements up to 10^{-5} amperes can be made at an accuracy of ± 2%, not including accuracy of input resistor.

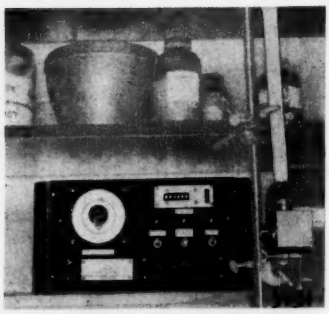
When used as a millivoltmeter the NA 100 model has 10, 100, and 1,000 mv ranges with extremely high input impedance — 10^{15} ohms. For micro-micro-ampere measurements, 10^{5} to 10^{13} ohm input resistors in decade steps are used.

Stability in such an instrument is of major importance. The drift in the NA 100 is less than ± 1 mv per day. This stability can be attributed in part to the exclusive, diaphragm-type dynamic capacitor and also to inherently stable AC amplification. The dynamic capacitor operates at a 1,000 cps carrier frequency and therefore discriminates against 60 cycle pick-up. Price F.O.B. Carlstadt, N.J., $1,075.00.

Write for Bulletin NA 100
Electronic Instruments Department

ELECTRONICS DIVISION
CURTISS-WRIGHT
CORPORATION · CARLSTADT, N. J.

For more information circle **107** on inquiry card.



Line voltage fluctuations produce no spurious counts and reliable operation in cold room is achieved by use of a tiny heater in phototube enclosure. Totalizer can be re-set to zero; drop number selector provides volumes up to 400 drops per sample (optional multiplier control doubles this capacity to 800 drops). Cable-adapter connects to any specific fraction collector.—*National Instrument Labs, Inc., 6108 Rhode Island Ave., Riverdale, Md.*

For more information circle **265** on inquiry card.

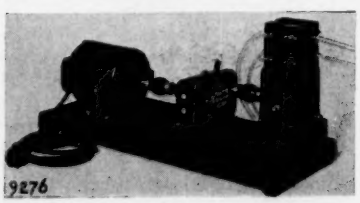
HEAVY-DUTY VACUUM OVENS

Two new large-capacity vacuum ovens: "Model 5850" has an 8" square Tuflex glass window. (Tuflex has a modulus of rupture of 30,000 psi, giving a safety factor of 20.) "Model 5840" is without glass door, has vacuum gage set in oven steel in center of door. Both have a 1½ cubic foot chamber, 12" square by 19" deep, and two adjustable shelves. Temperature range from room to 160°C.—*National Appliance Co., 7634 S. W. Capitol Hwy., Portland, Oregon.*

For more information circle **266** on inquiry card.

SMALL-FLOW PUMP

New "Model T-8" pump for medical, biological and industrial laboratories utilizes, as do larger Sigmamotor models, principle of moving steel



fingers in a wave-like motion over flexible tubing, to pump liquids, gases and slurries. This prevents contamination of liquid being pumped (or corrosion of pump parts). "T-8" ac-

commodates tubes of ¼", $\frac{3}{16}$", ⅛" and $\frac{1}{16}$" ID × $\frac{1}{16}$" wall, and $\frac{1}{32}$" ID × $\frac{1}{32}$" wall; gum rubber, silicone rubber, surgical gum latex, Neoprene or polyvinyl. Capacity range 0.1 to 250 cc/min. Standard unit includes a "Model 14 Revco Zero-Max" speed changer and a $\frac{1}{12}$ hp open motor with switch. Special motors available.—*Sigmamotor, Inc., 600 N. Main St., Middleport, N. Y.*

For more information circle **267** on inquiry card.

MICRO-BALANCE

New "Electrobalance" permits laboratories to perform micro weighing operations in a few seconds without

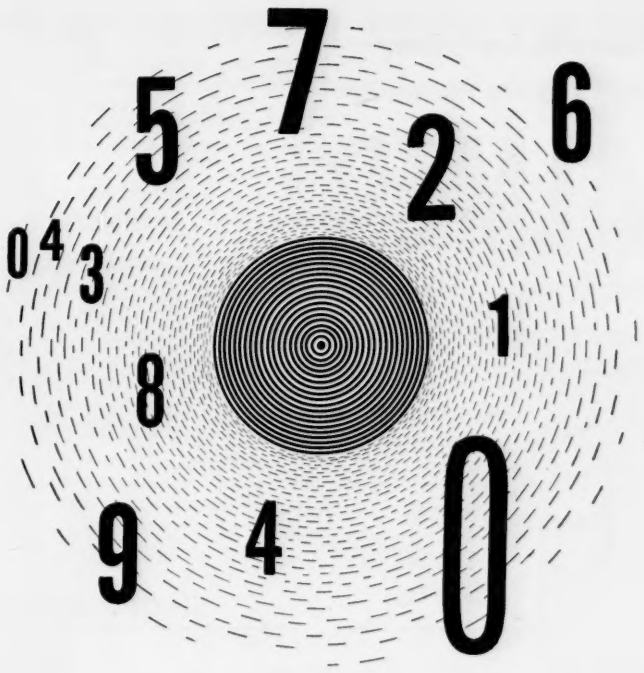
worrying about vibration, temperature, air currents, or levelling. It operates by electrically measuring torque; reads directly in micrograms; requires no skill to operate; is self-contained; needs no external power or utilities; takes a wide range of sample weights: 0-5, 0-10, 0-20 and 0-50 mg.—*Central Scientific Co., 1700 Park Rd., Chicago, Ill.*

For more information circle **268** on inquiry card.

PAPER ELECTROPHORESIS APPARATUS

New "Model R Paper Electrophoresis System" embodies design advancements intended to make paper-strip

electrophoresis procedures faster and more reproducible. Design improvements in "Analytrol" (recording scanner and integrator used with "Model R" system) include use of monochromatic light for scanning of stained separated strips and a new high-response servo amplifier, which together give operating curves approaching those of Beer's law and



analog-to-digital

KEARFOTT ANALOG-TO-DIGITAL CONVERTERS

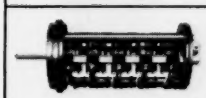
TRANSLATE SHAFT ROTATION INTO ELECTRICAL AND VISUAL DIGITAL FORM

KEARFOTT DIRECT DRIVE ADAC is a shaft-positioned analog-to-digital device utilizing coded drums, interconnected by high-speed odometer type gearing to provide an electrical impulse representing shaft position. Available for a wide variety of capacities and codings.

KEARFOTT MECHANICAL COUNTERS are used to provide precise visual presentations of angular position, latitude, longitude, or any information imparted by shaft rotation. Both types are designed to provide long life at maximum slewing speeds up to 1800 R.P.M.

KEARFOTT LATITUDE COUNTER

KEARFOTT ANGLE COUNTER


KEARFOTT ADAC (2[15]) 32,768

KEARFOTT ADAC 0° TO 359.9°

KEARFOTT COMPONENTS INCLUDE:
Gyros, Servo Motors, Synchros, Servo and Magnetic Amplifiers, Tachometer Generators, Hermetic Rotary Seals, Indicators and other Electrical and Mechanical Components.

KEARFOTT SYSTEMS INCLUDE:
Directional Gyro Compass Systems, Three Gyro Stable Platform Systems and Inertial Navigational Systems.

Send for bulletin giving data of components of interest to you.

KEARFOTT COMPANY, INC., Little Falls, N. J.

Sales and Engineering Offices:
1378 Main Avenue, Clifton, N. J.

Midwest Office:
23 West Calendar Avenue, La Grange, Ill.

South Central Office:
6211 Denton Drive, Dallas, Texas

West Coast Offices:
253 N. Vinedo Avenue, Pasadena, Calif.

Kearfott

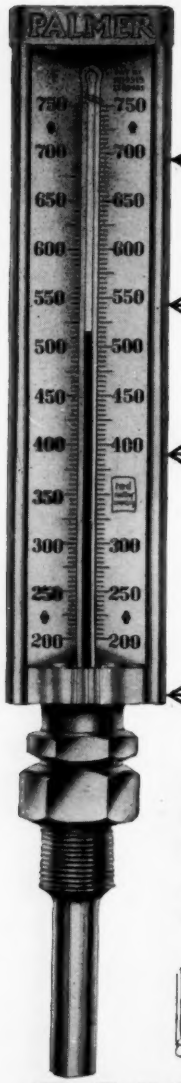
A SUBSIDIARY OF GPE
GENERAL PRECISION EQUIPMENT CORPORATION

For more information circle **108** on inquiry card.

Today's Modern Industry
Demands a Modern Thermometer

PALMER

RED-READING MERCURY THERMOMETERS



Red-Reading Mercury

Extruded Brass Case

Chrome Finish

Ranges -40 to 950°F or Equivalent in °C

Write for Complete Information

Ask for Bulletin No. 35

Find Your Palmer Representative In The 'Yellow Pages'

PALMER

THERMOMETERS, INC.
Mfrs. of Industrial Laboratory, Recording and Dial Thermometers
Cincinnati 12, O.

For more information circle **109** on inquiry card.

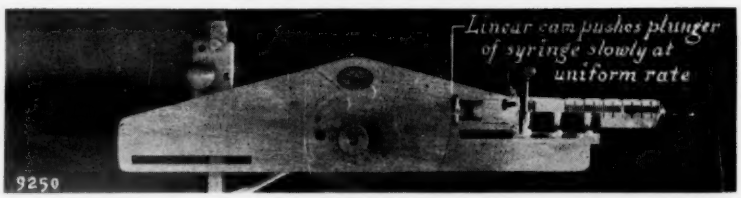
NEW INSTRUMENTS

providing reproducibility closely approximating that obtained by elution. Availability of various function cams for "Analytrol" permits its additional use as a colorimeter or densitometer.

All existing "Spinco Paper Electrophoresis Systems" can be modified to incorporate new features.—*Spinco Div., Beckman Instruments, Inc.*, 1171 *Stanford Industrial Park, Palo Alto, Calif.*

For more information circle **269** on inquiry card.

AUTOMATIC PRESET-RATE SAMPLE FEEDER



New "Sample Feed Device" permits wide range of sample sizes and of delivery periods by variations in motor speed (1 rev per week to 1 rph), in cam size and in syringe size.—*Microchemical Specialties Co.*, 1834 *University Ave., Berkeley 4, Calif.*

For more information circle **270** on inquiry card.

SHOP EQUIPMENT AND MATERIALS

PREFERRED CIRCUITS KIT

New "Dynamod" kit consists of storage case, breadboard, power distribution unit, connector cords, manual, blank circuit cards, and 23 different modular one-tube etched-card unitized circuit assemblies, all adhering to NBS "Preferred Circuit" design.—*Dale Boison Co.*, 2928 *Nebraska Ave., Santa Monica, Calif.*

For more information circle **271** on inquiry card.

CABLE HARNESS

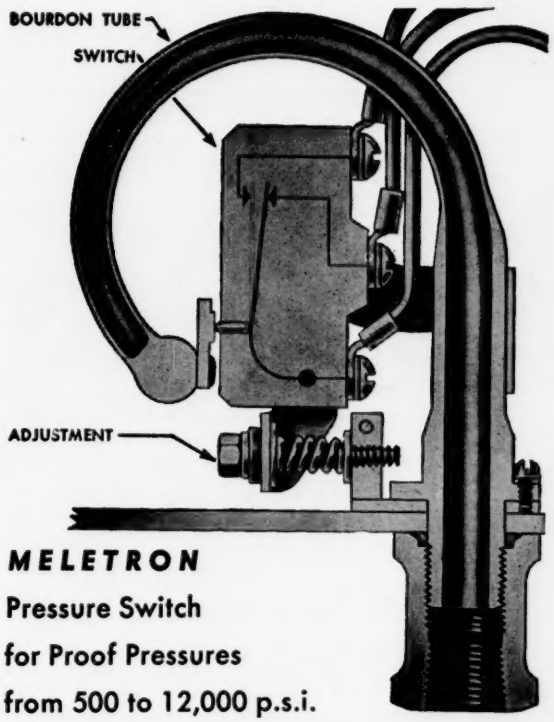
New "Spiral Wrap" simplifies harnessing of loose wires into neat cables. Made from polyethylene tubing in ¼" and ⅜" diameters and cut into a spiral pattern, it will wrap easily around loose wires to make cables in any diameter up to 2". Wires can be pulled out at any desired position. Available in white, red, and blue for color coding.—*Illumitronic Engineering*, 680 *E. Taylor, Sunnyvale, Calif.*

For more information circle **272** on inquiry card.

RESISTOR ALLOY

New precious-metal alloy for voltage-dividing resistor combines extremely high resistivity with a negative temperature coefficient of resistance; is said to make possible a number of improvements in VDR design, among them: (1) lower vulnerability to severe temperature change, (2) reducing size of some units while retaining a given resistance, (3) avoiding use of very fine wire—which often adds to manufacturing costs—without decreasing resistance; (4) lower vulnerability to atmospheric corrosion. Resistivity 1100 ohms/cmf; temperature coefficient -2.8×10^{-4} ohms per ohm per C degree between 0 and 100 degrees C.—*Baker & Co.*, 113 *Astor St., Newark 2, N. J.*

For more information circle **273** on inquiry card.



MELETRON
Pressure Switch
for Proof Pressures
from 500 to 12,000 p.s.i.

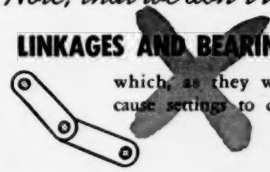
Competes on Price
Wins on Accuracy

EXTREMELY ACCURATE

Simplicity of direct acting design plus rugged precision construction make for long, unchanging repeat accuracy.

Note, that we don't use

LINKAGES AND BEARINGS



which, as they wear, cause settings to drift.

IN ANY POSITION

on moving equipment, even under vibration, switch performs with equal efficiency.

Because we don't use

LIQUID SWITCH ELEMENTS

which require that the pressure switch be mounted absolutely vertical, which make it very critical to vibration.

To get complete operating characteristics and specifications ask for bulletins 302 to 382.

BARKSDALE VALVES

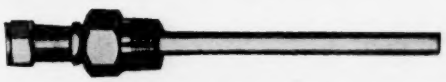
PRESSURE SWITCH DIVISION
5125 Alcoa Avenue, Los Angeles 58, California

For more information circle **110** on inquiry card.

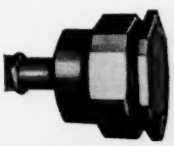
CONTROL WITHOUT CONTACT!

for non-conductive and semi-conductive materials— powders, semi-solids, viscous and corrosive liquids

Level tolerances as close as a fraction of an inch —or as great as several feet



This versatile, sensitive probe serves in dozens of *different* applications. It can be mounted vertically or horizontally depending upon the type of control required.



Excel Flush Probe is especially suited for control of abrasives, powders and other semi-solid materials. No moving parts. Nothing extends into bin or hopper.

EXCEL PROXIMITY RELAY

Complete circuit including DPDT relay is in this plug-in unit. Fits only the *right* way. No wires to disconnect. Interchangeable Plug-in Units eliminate down-time.

The Excel Proximity Relay is activated by a change in capacitance at a remote probe caused by the proximity of the movable material to be controlled.

A built-in power relay controls motor starters, solenoids, valves or signals making level control automatic. Complete instrument controls include a test button, relay position lights, and meter for accurate setting of sensitivity and balance. Exclusive coaxial cable (50' max.) connects relay and probe.

What Kind of Material Do You Want to Control?

Petroleum, food oils, grains, glue, sand, core and cutting oils, chemicals, acids and plastics are but a few of the materials that Excel Proximity Relays are controlling automatically for industry now.

The Excel Relay can solve problems for you also. Excel Engineers' experience is available to you without obligation. Write today giving details of your applications. Or write for Bulletin S-256 and Application Data Sheets.

XL-WAY

Service Since 1927

EXCEL
ELECTRIC SERVICE CO.

2115 S. Western Avenue
Chicago 8, Illinois

For more information circle **111** on inquiry card.

COMPUTER-SERIES PLUG-INS

Originally developed for EECO custom systems and proven in critical use, new EECO Computer-Series Plug-ins represent a refinement of the building-block concept to a degree hitherto unknown. Each of the full line of reliable, tested, and proven circuits is a complete off-the-shelf packaged function, performance-engineered for application where ultra-conservative design at the component level is essential because of system complexity.

New EECO Computer-Series Plug-ins enable you to meet your project delivery schedules by reducing systems-development time to a bare minimum and practically eliminating drafting and layout time. Your engineers can concentrate on system design instead of routine circuit detail. Your technicians can cut fabrication time and step up production by performing simple point-to-point wiring instead of wiring complex circuits. And system prototypes can generally be built directly without need for the "breadboard" stage.

Detailed information on new EECO Computer-Series Plug-ins and compatible equipment, as well as on other EECO products, is available in Catalog No. 856-A. Write for your copy—today.

ELECTRONIC ENGINEERS AND PHYSICISTS —EECO offers immediate opportunities for qualified engineers in the transistor, amplifier, data-handling, pulse, timing, and systems-design fields. Send a resume of your qualifications to R. F. Lander, Dept. CS-2.

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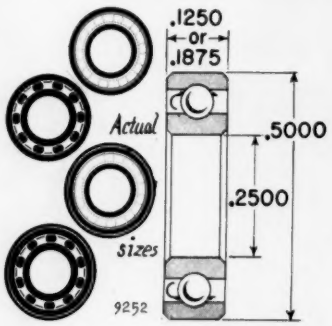
506 EAST FIRST STREET
SANTA ANA, CALIFORNIA

For more information circle **112** on inquiry card.

NEW INSTRUMENTS

INSTRUMENT BEARINGS

New "size No. 814" thin-section instrument ball bearings are available in 440-C stainless steel and SAE

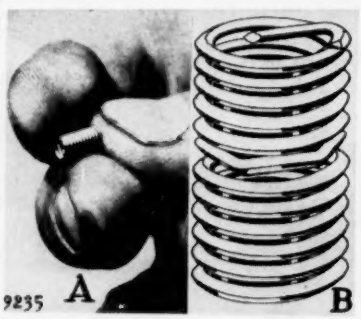


52100 high-carbon chrome steel. In both cases, snap type retainers of 430 stainless steel are used. Either single or double shield, with or without flange.—*Miniature Precision Bearings, Inc., Precision Park, Keene, N. H.*

For more information circle **274** on inquiry card.

LOCKING INSERTS

New miniaturized series of self-locking wire thread inserts covers a wide range of small precision appli-

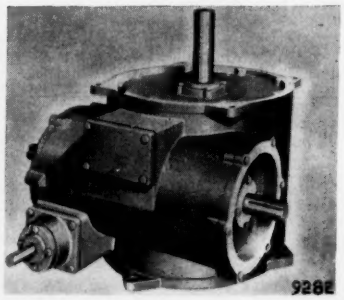


cations. New "4-40 Screw-Lock" series (Fig. A) provide answer to threaded fastening problems in miniature subassemblies where clearance or inaccessibility precludes use of external locking devices; obviates need for lock washers, lock nuts and locking wires with an integral gripping coil (Fig B). Locking effect remains through repeated cycles of disassembly and a locked screw can be readily freed by applying break-away torque about the same as used in original assembly.—*Heli-Coil Co., Danbury, Conn.*

For more information circle **275** on inquiry card.

INDEXING UNIT

New cam-operated indexing unit provides precision positioning between automatic production stations or to provide a simplified means of timing production operation drives. Input is either ¾ or 3 hp, depending on production per hour. Worm reduction 10:1, 20:1, or 40:1 as required. Increments of 8, 12, 16 or 20 can be ob-

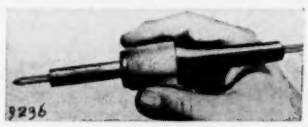


tained during one complete cycle or revolution of the index table. Camshaft extensions provide a simple means for operation of other production devices. Dimensions: 27" L, 26" W, 21¾" H over-all.—*Standard Tool & Mfg. Co., 237 Laurel Ave., Kearney, N. J.*

For more information circle **276** on inquiry card.

50-W SOLDERING PENCIL

New 50-watt soldering pencil with long-life ¼" tip can do the work of 100-watt soldering irons, yet weighs



2 oz. Operates on 110 or 120 v dc or ac.—*Hexacon Electric Co., 295 W. Clay Ave., Roselle Park, N. J.*

For more information circle **277** on inquiry card.

INSULATION STRIPPER

New hand type stripper makes Teflon as easy to strip as any other insulation, owing to unique blade construction, holding power of broad jaws and matched sets of blades precision drilled on watchmaker's equipment to correct hole size for each size of wire. Two new features: (1) "Short-Stop" latch to protect wire strands by only partly stripping individual leads; (2) adjustable "Transparent Wire Stop" for uniform stripping and for visibility when placing wire in stripping holes.—*Ideal Industries, Inc., 1420 Park Ave., Sycamore, Ill.*

For more information circle **278** on inquiry card.

LOW-SHRINKAGE SILICONES

Three new low-shrinkage silicone rubber compounds for O-rings and other molded parts (#76-128, #77-248, and #78-138, with 60, 70, and 80 Shore A Durometer hardness) meet specifications AMS 3303, 3304, and 3305; are suitable over a temper-

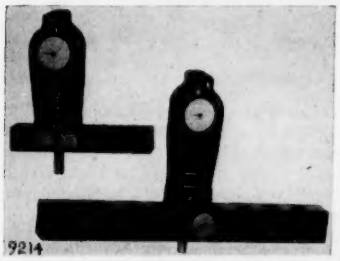
ature range of −80°F to 500°F. Heretofore, most silicone compounds have shown troublesome shrinkage when molded. New materials can be handled in standard molds as used for regular synthetic rubber compounds, and come out to AN size and tolerance.—*Rubber Products Div., Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio.*

For more information circle **279** on inquiry card.

INSPECTION & GAGING

INDICATOR DEPTH GAGES

New standard series of interchangeable components makes it possible to select a completely standard indica-

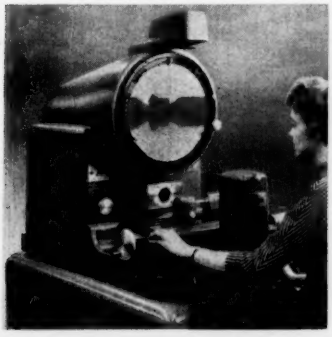


tor depth gage for practically any part condition: over 3500 standard depth gages can be specified without alterations of standard components. All standard models can be easily set to either gage blocks or a master set gage. Any popular-make indicator can be furnished with gage.—*A. G. Davis Gage & Eng. Co., 21435 Dequindre Road, Hazel Park, Mich.*

For more information circle **280** on inquiry card.

CONTOUR PROJECTOR

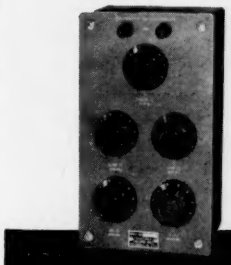
New "Model 14-6 Kodak Contour Projector" embodies a micrometer device for horizontal measurements;



features ample table travel to simplify staging; includes as standard equipment a movable work table with both horizontal and vertical traverse. Option: measurement system providing "magnified" micrometric measurements for tool-room optical gaging.—*Optical Gaging Products, Inc., Rochester 11, N. Y.*

For more information circle **281** on inquiry card.

DECADE RESISTANCES



DECADE BOX

. . . with precision wirewound resistors mounted on steatite-insulated switches. *TEN* resistors per decade . . . giving better than 0.1% accuracy above 10 ohms.

Type	Dials	Ohm Steps	Total Resistance—Ohms	Price
817	3	0.01	11.1	$60.00
818	3	0.1	111	51.00
820	3	1	1,110	56.00
821	3	10	11,100	60.00
822	3	100	111,000	63.00
823	3	1,000	1,110,000	77.00
824	3	10,000	11,100,000	120.00
817-A	4	0.01	111.1	75.00
819	4	0.1	1,111	71.00
825	4	1	11,110	77.00
826	4	10	111,100	79.00
827	4	100	1,111,000	92.00
828	4	1,000	11,110,000	139.00
8285	5	0.1	11,111	94.00
829	5	1	111,110	101.00
830	5	10	1,111,100	113.00
831	5	100	11,111,000	155.00
817-C	6	0.01	11,111.1	105.00
8315	6	0.1	111,111	109.00
832	6	1	1,111,110	121.00
833	6	10	11,111,100	169.00

UNMOUNTED DECADE

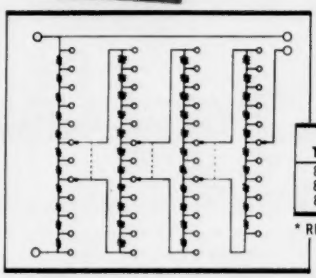
Type*	Dials	Ohm Steps	Total Resistance—Ohms	Price
435	1	0.1	1	$12.00
436	1	1	10	13.25
437	1	10	100	13.25
438	1	100	1,000	15.00
439	1	1,000	10,000	16.00
440	1	10,000	100,000	18.50
441	1	100,000	1,000,000	32.50
442	1	1,000,000	10,000,000	60.00

* Knob (#M-25594) not included. Available at additional cost.

Shallcross

DECADE VOLTAGE DIVIDERS

. . . same quality construction as in Decade Resistances. Choice of Kelvin-Varley or conventional potentiometer circuits.

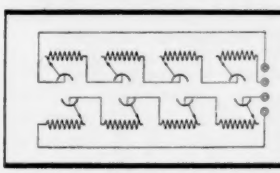


KELVIN-VARLEY CIRCUIT

Type	Dials *	Input Resistance (Accuracy ±0.05%)	Price
8350	4	10,000	$140.00
8349	4	50,000	145.00
8348	4	100,000	150.00

* RESOLUTION—Any ratio between 0.0000 and 1.0000 in steps of 0.0001.

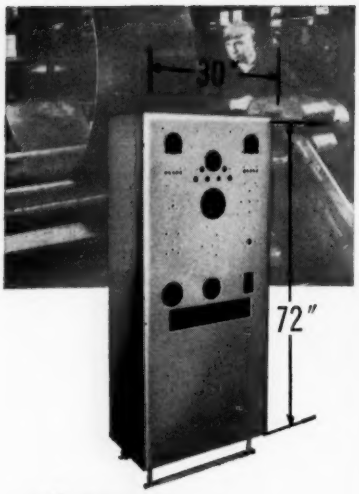
POTENTIOMETER CIRCUIT



Type	Dials	Ohm Steps	Total Resistance (Accuracy ±0.1%)	Price
837	4	0.1	1,000	$126.00
835	4	1.0	10,000	139.00
836	4	10.0	100,000	146.00
849	5	0.1	10,000	165.00
848	5	1.0	100,000	176.00

SHALLCROSS MANUFACTURING COMPANY, 510 Pusey Avenue, Collingdale, Pa.

For more information circle **113** on inquiry card.



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Any product is improved by better packaging—that's one reason why costly electrical or control mechanisms deserve cabinets, panels or boxes made to Cincinnati Ventilating's high standards of quality. We custom fabricate sheet metal to individual specifications, in any quantity. We are equipped to make almost any sheet metal part; we can stamp, shear, break, roll, weld, machine, assemble and finish all types of metal — aluminum, brass, copper, monel, stainless and all other steels. We have the facilities and the personnel to produce consistently top quality work, at competitive prices.

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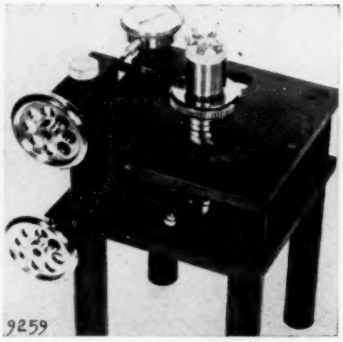
NEW INSTRUMENTS

DIVIDER HEAD

New precision divider head, widely adaptable for testing rotating instruments and components within extremely close limits, can be used advantageously in production lines, inspection departments and labs. Operation is said to be simple and highly efficient, preventing operator fatigue and minimizing chance of human error. Testing errors are non-accummulative and no error can be introduced by forces caused by shaft runout. Units can be mounted top and bottom, "back to back," for simultaneous testing with individual adjustment of standard and unknown. Angular errors are directly displayed and 360 points, from 0° to 360°; can be checked by making only 10 settings. Mounting arm (a key feature) is claimed to be the only adapter required. Price is lower than that of conventional divider heads.—*Path Engineering & Machined Products, 1048 Pico Blvd., Santa Monica, Calif.*



For more information circle **282** on inquiry card.

MICROMETER STAGE

New 1"×6" measured-travel coordinate stage, designed primarily for use with maker's lines of optical comparators, can be used also with microscopes or other means of optical observation. Accurate measured coordinate travel in 1"×6" range is provided by means of hardened and ground preloaded precision ball vee ways. Readings are made on a choice of micrometers: 0.0005" increments or 0.0001" increments. Two 2.000" and one 1.0000" size blocks are standard equipment.—*Stocker & Yale, Inc., Marblehead, Mass.*

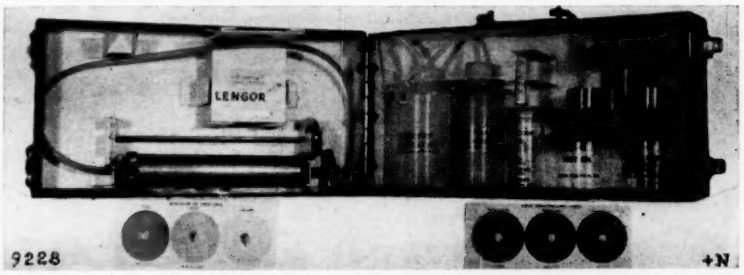
For more information circle **283** on inquiry card.

MECHANICAL TESTING

LUBRICATING OIL TESTING KIT

New "Simplex" kit improves preventive maintenance by detecting contaminants and fuel dilution in used lube oils. It comprises instruments and accessories for making about ten tests and determinations.—*Gardner Laboratory, Inc., 5521 Landy Lane, Bethesda 14, Md.*

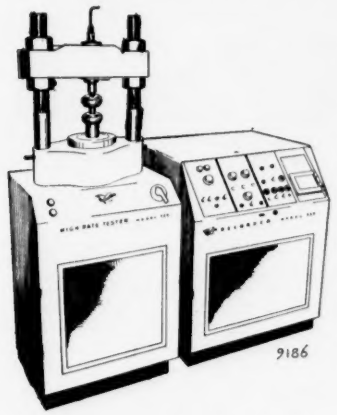
For more information circle **284** on inquiry card.



HIGH-RATE TENSILE AND COMPRESSIVE TESTER

New "Alinco Model 625 High Rate Tension and Compression Tester," first of its type, provides a completely calibrated stress-strain record of the deformation of a specimen, at rates as high as 6000 ipm; can be operated by non-skilled personnel; permits thorough investigation of ultimate yields, elastic moduli, temperature effects, etc., "at a cost that is not prohibitive." Procedure: Operator clamps specimen in tension or compression jaws; he then presses CALIBRATE button, and a series of dots is placed on a photographic record in a fraction of a second. These dots represent increments of stress in vertical direction, and strain in hori-

zontal directions. Operator then presses OPERATE button and specimen is distorted at a constant preselected rate. Both distortion (strain) and

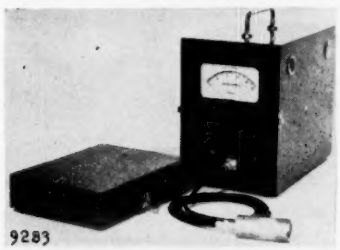


load (stress) are photographically recorded as a stress-strain curve. In addition, timing dots are put on record while specimen is being stressed. —*Allegany Instrument Co.*, 1091 *Willis Mountain, Cumberland, Md.*

For more information circle **285** on inquiry card.

BOND TESTER

New "R. C. Bond Tester" measures relative shear strength of metal bonded structures; indicates directly



in psi; has uniform sensitivity over a range of 0.16 to 0.063 skin gages. Sensitivity is sufficient to indicate variations in thickness of bond line. Especially useful where a portable instrument is necessary.—*The Standel Co.*, 10661 *Freer St., Temple City, Calif.*

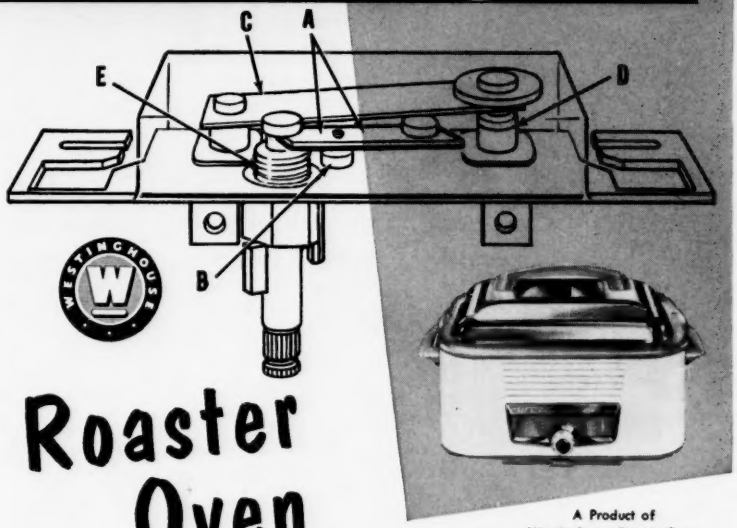
For more information circle **286** on inquiry card.

DYNAMIC STRAIN ANALYZER

New "PA-2A" provides stable amplification and precise control required for accurate measurement and

'scope display of static and dynamic strain. Useful sensitivity (dependent

HOW CHACE THERMOSTATIC BIMETAL CONTROLS THE Westinghouse



Roaster Oven

A Product of
Westinghouse Electric Corp.
Mansfield, Ohio

A versatile servant is the new Westinghouse Electric Roaster-Oven which can be used to bake anything from a 14 lb. turkey to a complete oven meal. With its accessory, the broiler grid, it also can be used for broiling, grilling and frying. Of course, the actuating element in this modern appliance is reliable Chace Thermostatic Bimetal.

Here's how it works: The thermostatic bimetal element (A) is mounted freely on the fulcrum pin (B), in a position exposed to radiation from the roaster heating element. The current is carried by the leaf spring (C) through the contacts (D). As the ambient temperature in the roaster increases, the bimetal element (A) deflects in the direction of the spring (C), until the insulated tip presses against the spring and opens the contacts (D). The temperature then drops, the bimetal returns, the contacts meet and this cycle repeats. Since the notched end of the bimetal element is engaged in the groove in the threaded stem (E), turning the control knob clockwise moves the bimetal away from the spring, thus prolonging the contact time and raising the cooking range.

Remember Chace when you design for temperature actuation or indication, or for protection of valuable equipment. Dependable Chace Thermostatic Bimetal is available in 28 types, in strip, coil or completely fabricated and assembled elements made to your specification. Write for new 44-page booklet, "Successful Applications of Chace Thermostatic Bimetal," containing interesting uses of bimetal and many pages of engineering data.

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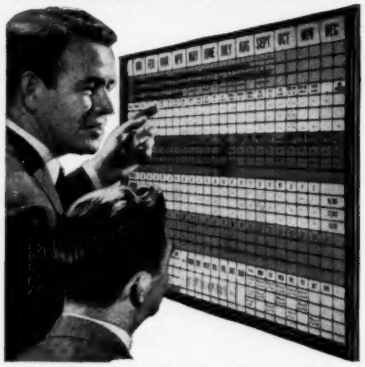

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3 Times Greater Light Efficiency
. . . because a new, tiny Alden bulb (only 1/4 the size of miniature bayonet bulbs) is sealed high up in its own translucent lens and mounted in front of the panel to provide maximum indication. that is . . .
(75% BULB EFFICIENCY)

Visible From Any Angle — Any Distance
Lens glows like a red hot poker in a 180° arc.

Non-Refracting — Unobtrusive When Unlit
Even brightest outside lights will not cause false indication

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Merely drill a .348" hole and snap-in for mounting. Holds fast under shock or vibration. Bulb lens assembly replaces from front of panel.

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For more information circle **117** on inquiry card.

NEW INSTRUMENTS

upon low amplifier noise) is attained by combining a high-quality 400-cps chopper and amplifier, resulting in noise level of about 3 uv. Amplifier frequency response is flat from 5 cps to 50 kc. Any resistive type strain gage can be used. Two strain measuring ranges, ±5,000 and ±10,000 microinches per inch, read directly on a 10-turn dial.—*Polyphase Instrument Co., Bridgeport, Penna.*

For more information circle **287** on inquiry card.

NON-DESTRUCTIVE COATING THICKNESS TESTER

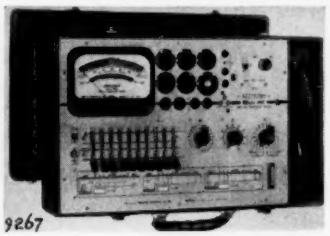
New "Dermitron Model D-2," for lab and production use, gives direct readings of virtually any coating on any base, including: metal coatings (such as plating) on metal base; non-metallic coatings (such as paint, anodizing, porcelain) on metal base; and metal films on non-metallic base (plastics, ceramics). It comes with four measuring probes for thickness ranges from thin to thick deposits, requires only a 1/8" circle-area for measurement; can also be used for sorting and matching of metals and alloys.—*Unit Process Assemblies, Inc., 61 E. 4th St., New York, N. Y.*

For more information circle **288** on inquiry card.

ELECTRICAL and ELECTRONIC INSTRUMENTS

TUBE CHECKER AND TUBE & TRANSISTOR TESTER

New "Model 640" cathode conductance tube tester features unusually versatile performance as an emission tester; tests all modern TV and radio tubes; has a free-point 10-lever element selector system. ★"Model 660" tube and transistor tester (illus), though in "medium-price category," incorporates all tube-testing features of "640" and provides also comprehensive tests on all RF, AF, power and tetrode transistors for I_{CBO}, gain, leakage, etc.; also tests crystal diodes for both forward and reverse current, and has special circuitry for beam-current testing all popular TV picture tubes.—*Precision Apparatus Co., 70-31 84th St., Glendale 27, Long Island, N. Y.*



For more information circle **289** on inquiry card.

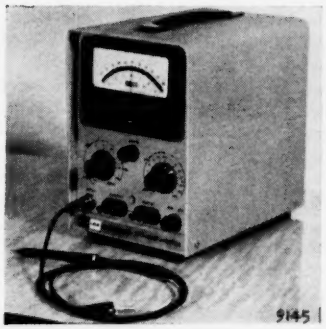
AUTOMATIZED TUBE TESTER

New "Model 123A Cardmatic Tube Testing Machine" utilizes a punched card system to automatically set and test to a user's specific circuit requirements. Preselected voltages on screen, plate, grid or filament are tabulated on vinyl type cards which are inserted into tester and trip a mechanism to make all electrical connections necessary for testing of any receiver tube. Infinitely large number of exactly-controlled voltages (formerly possible only in lab type testers) available for testing tubes in special purpose circuits. Unusually low signal used on grid permits testing of newer "sensitive" types without distortion. Tubes are checked within seconds. Unskilled personnel can run lab-accuracy tests on a production line basis.—*The Hickok Electrical Instrument Co., 10519 Dupont Ave., Cleveland 8, Ohio.*

For more information circle **290** on inquiry card.

MULTI-RANGE TESTER

New "Model 203" combination dc microvoltmeter, microammeter, and amplifier employs maker's chopper amplifier circuit to provide exceptionally good stability and accuracy. Fifteen voltage ranges from 100 uv to 1000 v full-scale; ten current ranges from 100 uua to 100 ma full-scale. Zero-center indicator has two



mirror scales which cover all ranges. Output terminals on front panel allow instrument to be used as a low-drift dc amplifier with up to 80 db gain and extremely high input impedance. Drift after 15 min. warm-up is less than 10 uv and accuracy is 3% on all ranges. Available in cabinet or 19" rack-mount models.—*Kin Tel (Formerly Kay Lab), 5725 Kearny Villa Road, San Diego* vv, *Calif.*

For more information circle **291** on inquiry card.

INSULATION TESTER

New "P-3" combines "Sensitive Hi-pot Tester" with "Fault Indicator and Counter" for continuous production

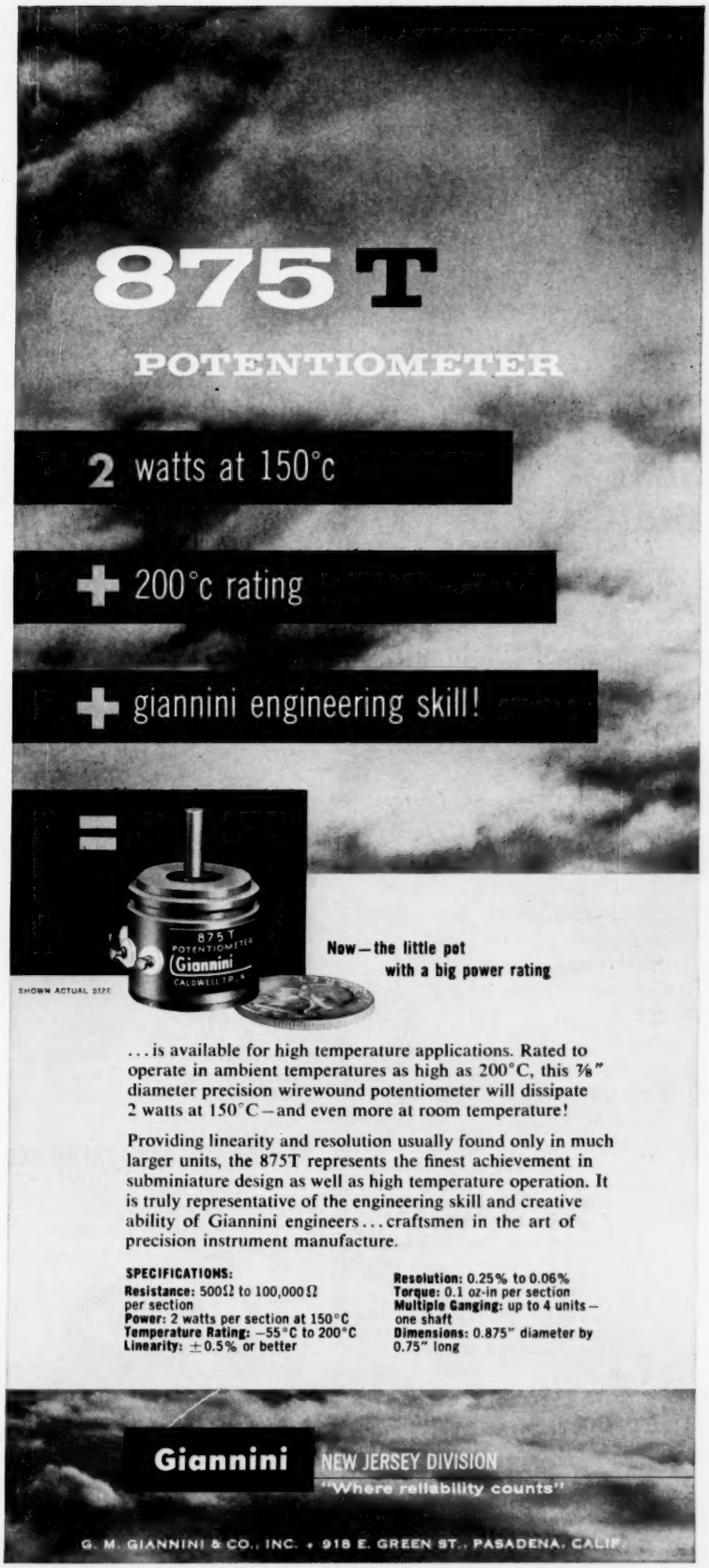
use in manufacture of insulated wire or other material. It is a dual unit, making possible testing for two types of insulation faults: pinholes and substandard insulation. It has two variable power supplies. By energizing forward electrode with a suitably low potential (100 v) and following electrode with high voltage (up to 20,000) user obtains separate indications and counts for both types of faults.—*Peschel Electronics Inc., 15 Garden St., in New Rochelle, N. Y.*

For more information circle **292** on inquiry card.

FM TELEMETRY DISCRIMINATOR

New "Model FM-108 FM-to-Voltage Converter" features (1) long-term stability that makes it unnecessary to correct for component aging, thermal drift, or gain variations; (2)

For more information on products reported or advertised in this issue, use handy card on page 1217.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POTENTIOMETER
2 watts at 150°c
+ 200°c rating
+ giannini engineering skill!
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POTENTIOMETER
Giannini
SHOWN ACTUAL SIZE
Now—the little pot
with a big power rating
...is available for high temperature applications. Rated to operate in ambient temperatures as high as 200°C, this ⅞" diameter precision wirewound potentiometer will dissipate 2 watts at 150°C—and even more at room temperature!
Providing linearity and resolution usually found only in much larger units, the 875T represents the finest achievement in subminiature design as well as high temperature operation. It is truly representative of the engineering skill and creative ability of Giannini engineers...craftsmen in the art of precision instrument manufacture.
SPECIFICATIONS:
Resistance: 500Ω to 100,000Ω per section
Power: 2 watts per section at 150°C
Temperature Rating: −55°C to 200°C
Linearity: ±0.5% or better
Resolution: 0.25% to 0.06%
Torque: 0.1 oz-in per section
Multiple Ganging: up to 4 units—one shaft
Dimensions: 0.875" diameter by 0.75" long
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For more information circle **118** on inquiry card.

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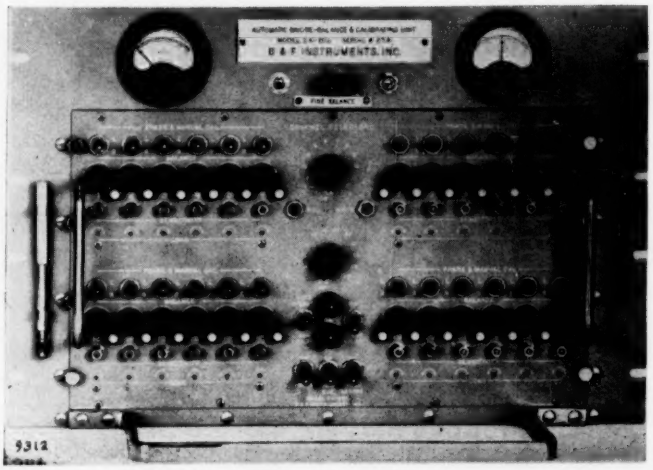
For more information circle **119** on inquiry card.

NEW INSTRUMENTS

absolute accuracy of 0.05%; (3) dynamic accuracy better than 0.2% for life of equipment; (4) operation on any of the 23 standard IRTWG telemetering sub-frequencies from 400 cps to 70 kc; (5) band switching remotely or by selector switch on front panel; bandswitch also automatically puts correct low-pass filter value in output; (6) 62 low-pass filter bandwidths, from 11 to 3490 cps, separately selectable if standard low-pass filter frequency is not desired.—*Epsco, Inc.*, 588 *Commonwealth Ave., Boston* 15, *Mass.*

For more information circle **293** on inquiry card.

AUTOMATIC-CALIBRATING BRIDGE BALANCE UNIT

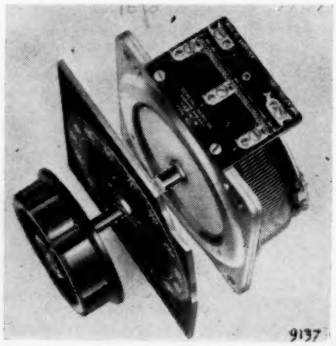


New "Model 24-202" embodies advanced technique of Series Calibration; obviates need for data reduction personnel to "average through" calibration pulses or "fair" zero and base line references; is said to be "of great value in missile range instrumentation systems and in flight test programs of advanced military aircraft." It saves time and effort for balance, control and series calibration of strain gages, acceleration pickups, pressure cells and other resistive-type pickups and is of special value when recording dithering type information: it provides calibration steps that are truly square-wave for clearer interpretation. It features independent adjustments for each channel of: voltage (individual channel control switches); balance; galvanometer damping (shunt and series); sensitivity; calibrating level and phase.—*B & F Instruments, Inc.*, 4732 *North Broad Street, Philadelphia* 41, *Pa.*

For more information circle **294** on inquiry card.

20-AMP AUTOTRANSFORMER

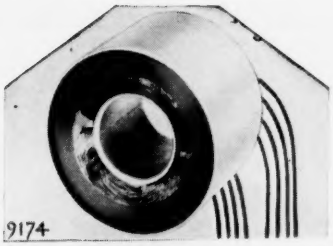
New "Type M20 Variac" permits operation at any supply frequency between 350 and 1200 cps; is rated at 115 v input with output up to 20 amp at 0 to 115 or 0 to 135 v; is ruggedized, tropicalized, and designed to withstand MIL enviromental operational shock and vibration tests.—*General Radio Co.*, 275 *Massachusetts Ave., Cambridge* 39, *Mass.*



For more information circle **295** on inquiry card.

MINIATURE YOKE

New "Type Y-57-P" miniature epoxy-encapsulated push-pull magnetic deflection yoke fits all standard ⅞" neck dia CR tubes with deflection angle up to 70°. Push-pull windings with separate B+ leads permit circuit flexibility. Available in impedances and winding configurations suitable for transistor drive and in



higher impedances for vacuum-tube circuits. Residual is 0.5% max; radial error 1% max; angular error 0.5° max; horizontal coil capacity 11 mmf, vertical coil capacity 15 mmf; temperature rating 105° C max.—*Syntronic Instruments, Inc.*, 170 *Industrial Rd., Addison, Ill.*

For more information circle **296** on inquiry card.

LOW-LEVEL DIGITAL VM

New "Model 460" digital voltmeter is said to make possible "for the first time, rapid accurate measurement of

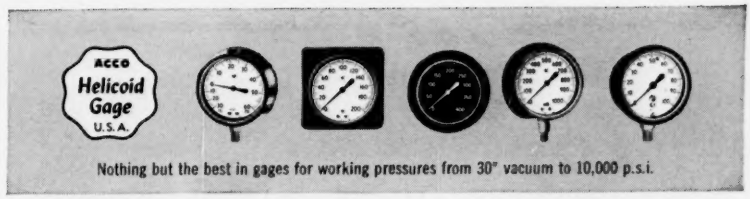
low level dc voltages from thermocouples, strain gages, and transducers." Range 0.001-9.999 mv (pos. or neg.). Instrument does not require a preamplifier, nor does it use pots or slide wires. Features: (1) stepping switches immersed in oil to minimize wear and maximize reliability: switch life increased by four times over normal dry operation; (2) connection and automatic print control for operation of Clary Printers and IBM Summary Punch; (3) available in complete custom-built data-recording systems utilizing printers, tape punch and electric typewriters. Other accessories include multi-channel input scanner, and remote digital readouts. —*Non-Linear Systems, Inc., Del Mar, Calif.*

For more information circle **297** on inquiry card.

VACUUM-TUBE VOLTMETER

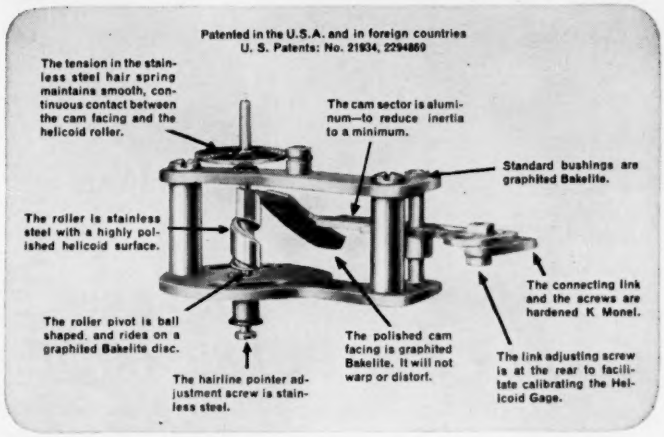
New VTVM is said to achieve long-time stability and accuracy through use of balanced circuits, liberal inverse feed-back, and precision components. It measures dc (plus or minus) from 1 to 1000 v in seven ranges, ac from 1 to 300 vrms in seven ranges, and resistance up to 500 megohms by means of seven multipliers. Accuracy of dc voltage measurement is 2% full-scale; of ac 3%

If the inquiry card (page 1217) has already been used, send inquiry number on postal card in care of our "Reader Service Dept."



Nothing but the best in gages for working pressures from 30" vacuum to 10,000 p.s.i.

These details of Helicoid gage design assure longer life and enduring accuracy


Patented in the U.S.A. and in foreign countries
U. S. Patents: No. 21934, 2294869
The tension in the stainless steel hair spring maintains smooth, continuous contact between the cam facing and the helicoid roller.
The cam sector is aluminum—to reduce inertia to a minimum.
Standard bushings are graphited Bakelite.
The roller is stainless steel with a highly polished helicoid surface.
The connecting link and the screws are hardened K Monel.
The roller pivot is ball shaped, and rides on a graphited Bakelite disc.
The polished cam facing is graphited Bakelite. It will not warp or distort.
The link adjusting screw is at the rear to facilitate calibrating the Helicoid Gage.
The hairline pointer adjustment screw is stainless steel.

The superiority of Helicoid Gages is most evident in severe service—wherever a gage is subjected to violent pressure pulsations or severe mechanical vibrations.

The *sustained accuracy* of Helicoid Gages over *millions of cycles* is explained by the details of design and construction of the Helicoid movement shown above. Such Helicoid features—protect against wear and corrosion and assure sensitivity, sustained accuracy and trouble-free operation.

Easiest adjustment and calibration

Only Helicoid Gages have the external pointer adjustment pictured here. The Helicoid type adjustment cannot be jarred out of position.

Calibration of Helicoid Gages is accomplished easily, without removing dial or pointer, because the link adjusting screw is at the rear of the system.

Tubes built for millions of pressure pulsations

To fit the wide range of applications, Helicoid Bourdon tubes are available in four materials —alloy steel, K Monel, stainless steel and phosphor bronze.

All Helicoid tubes are made from seamless tubing and are carefully designed to give maximum torque and minimum stress. When used within the dial range, they will withstand many millions of pressure pulsations and will not stretch, leak or crack.

For complete information on the Helicoid line of gages write for **Catalog G-52**

Helicoid gives you all these features at prices that are competitive in the quality gage field.

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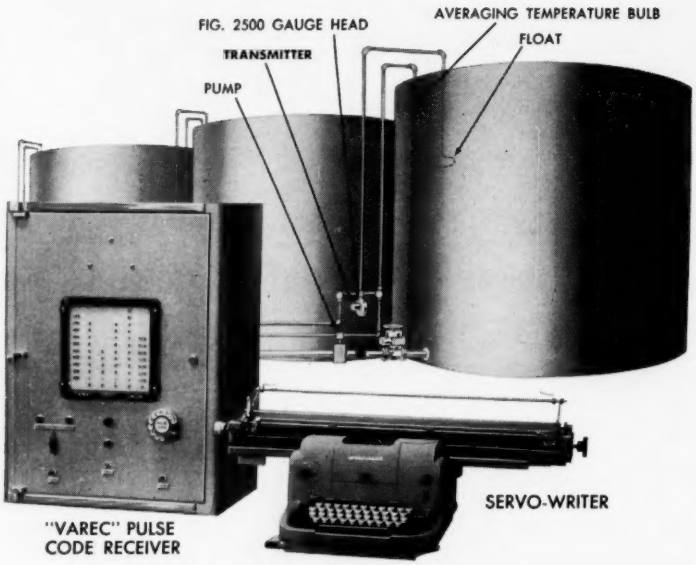
ACCO
TRADE MARK

For more information circle **120** on inquiry card.



If You're "Automating" Compare "Varec" PULSE CODE

"Varec" PULSE CODE Telemetering can give you an accurate transmission system over unlimited distance for remote gauging of liquid level, temperature reading, and remote control of valves and pumps. A printed record can be provided by an electric typewriter.

Here's why . . .

1. "Varec" PULSE CODE is a true digital system. It avoids the variations of reading caused by interpolation of analog systems.

2. "Varec" PULSE CODE and the pulse count systems are the only true digital systems. In the PULSE CODE system, pulses are arranged to code groups of numbers. Each element of the code or each pulse has two possible conditions, or short and long (also called dot and dash).

The pulse count system relies on transmitting, receiving and counting a number of pulses to represent intelligence. For example, to telemeter the number 10, ten pulses are transmitted and then "counted" by the receiver. The pulse count may send 10 pulses for 10, but due to variations in the power supply, receive and indicate only nine. Whereas, if "Varec" PULSE CODE lost a pulse in transmission for any reason, the signal would make no sense to the receiver. So it refuses to provide any indication, which is better than indicating an error. Same action would occur if an extra pulse were received.

"Varec" PULSE CODE provides immunity from errors caused by changes in signal during transmission.

3. "Varec" PULSE CODE transmits a message in one-fifth of the time required by a pulse count system.

4. To prevent errors of as much as one foot during a gauging cycle, pulse count transmitter must be locked up during gauging cycle to prevent a change in reading, thus the possibility of permanently locking the transmitter is present. No such gadgets are needed by "Varec" PULSE CODE because of the unique characteristics of the code. A signal can be transmitted while the transmitter is changing without errors being produced.

5. "Varec" PULSE CODE Telemetering System is based on good operational theory.

If you are planning a remote gauging and control system, you'll want the whole story. Send for "A Comparison of Current Telemetering Systems". It's free!

THE VAPOR RECOVERY SYSTEMS COMPANY

"Varec"

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Compton, California

CABLE ADDRESS:
VAREC COMPTON CALIFORNIA (U.S.A.) All Codes **961-21**

For more information circle **121** on inquiry card.

NEW INSTRUMENTS

full-scale. Frequency response 1 db from 10 cps to 700 mc. Input impedance for dc measurement 100 megs; input capacitance of the ac probe is extremely low (1.2 mmf).—*Acton Laboratories, Inc., Acton, Mass.*

For more information circle **298** on inquiry card.

LOW-RANGE OHMMETER

New "Model 362 Low-Ohm-Meter" features accurate measurements of low resistance values and utilizes low circuit currents; gives readings from 0.1 to 25 ohms. Accuracy of 3% of full-scale value is attained by using expanded scale suppressed-infinity shunt-type ohmmeter. Another feature is its circuit current of only 5 ma maximum, which prevents damage to low-current components and promotes long battery life. Two Ranges: 0-5 ohms and 0-25 ohms.—*Simpson Electric Co., 5200 West Kinzie St., Chicago 44, Ill.*

For more information circle **299** on inquiry card.

PULSE CALIBRATOR

New "Type 1810 Pulse Calibrator," for accurately measuring current and voltage pulse amplitudes, pulse dur-

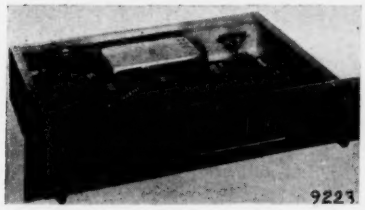
ations and rise time, permits visual display and comparison of two signals: One (to be measured) can be ac, dc, or a pulse of either polarity; the other is a known reference voltage, which can be varied by means of a precision helical attenuator with a calibrated dial having 1,000 divisions. Accuracy of calibrating voltage

is maintained at better than 0.1% and output amplitude can be measured in millivolts or milliamps.—*Burroughs Corp., Electronic Instruments Div., 1209 Vine St., Philadelphia 7, Pa.*

For more information circle **300** on inquiry card.

DIGITAL OHMMETERS

New 4- and 5-digit ohmmeters feature maker's exclusive modular construction; are made up of two mod-



ules: "Universal Power Module," and "Resistance Switch Module" which contains all three arms of a full Wheatstone bridge as well as visual read-out. Wider dynamic range: automatic resistance measurements from 10 milliohms to 10 megohms with a single instrument. Ranging is automatic but controlling contacts are available at rear panel for programmed ranging. New circuit logic improves balance time and always provides the largest number of significant digits on down ranging.—*Electro Instruments, Inc., 3794 Rosecrans, San Diego, Calif.*

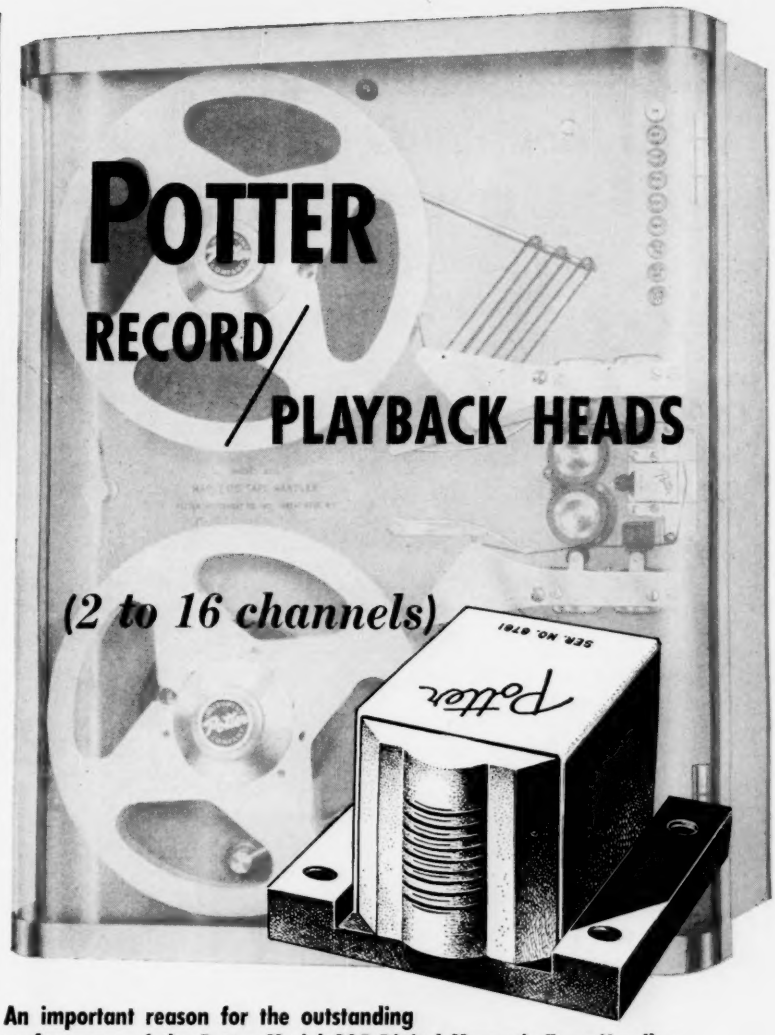
For more information circle **301** on inquiry card.

FREQUENCY METER

New "Model 503," lightweight and fully transistorized, provides direct frequency measurements from 3 to

100,000 cps in nine ranges (60 to 6,000,000 rpm optional). Accuracy is independent of input voltage waveform and amplitude. Sensitivity to short pulses minimizes lost counts when measuring average frequency of random events. Battery or ac powered. ★"Model A-503-1" and "Model A-503-2" phototransistor pickups allow speed of rotating machinery or frequency of vibrating parts to be sensed by means of interrupted light. —*Cubic Corp., 5575 Kearney Villa Rd., San Diego 11, Calif.*

For more information circle **302** on inquiry card.



An important reason for the outstanding performance of the Potter Model 905 Digital Magnetic Tape Handler

Precision designed to meet highest standards of performance and reliability... *machined bronze... solidly constructed to close tolerances... high dimensional stability... full shielding between channels... precisely aligned gaps.*

Track width:	.020″ to .031″ ± .001″
Track spacing:	.078″ to .050″ ± .001″
Gap width:	.0005″
Gap alignment:	Within .0001″
Impedance:	Nominal 10 mhy for tube record amplifiers Nominal 1 mhy for transistor record amplifiers *(Available with both high and low impedance windings on each channel)*
Record Current:	10 mhy: 10 ma. 1 mhy: 30 ma. Rise time: 1 μ sec
Signal level:	Nominal 10 mv. for 10 mhy winding at 30 ips
Signal/noise:	Full shielding gives playback S/N 40 db or better

Gap, track width, track spacing and nominal inductance can be varied within reasonable limits for custom applications.

For more information, prices and delivery schedules on heads and tape handlers, write, wire or phone your Potter representative or the factory.

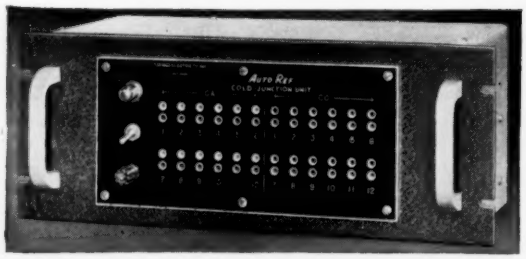
Potter **POTTER INSTRUMENT COMPANY, INC.**
115 Cutter Mill Road Great Neck, L.I., N.Y.

For more information circle **122** on inquiry card.

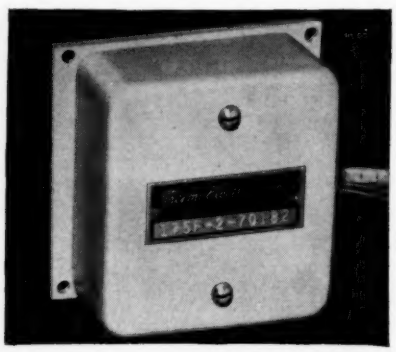
Specialized

Cold Junction Compensation For Thermocouple Circuits

With T-E's AUTOREF Units



Standard "AutoRef" This unit provides a constant cold-junction temperature reference when temperature must be measured together with many other D.C. signals—as on multi-point recorders and data reduction systems. Desired cold-junction temperatures can be controlled to within ±1°F. over a wide range of ambient temperatures. And you can introduce the "AutoRef" anywhere in the thermocouple circuit. Designed for convenient panel rack mounting, it is available for all standard calibrations. Capacities up to several hundred T/C circuits.



Miniature "AutoRef" A compensating bridge-type unit, the miniature "AutoRef" is of great advantage where measured temperatures will vary widely both above and below ambient temperature. Reference temperature can be pre-selected below lowest expected measured temperature—thus eliminating any reversal of circuit voltage polarity. This cold-junction unit features: (1) extremely small size—only 1¼" x 3" x 3⅝"; (2) light weight —just 12 oz.; (3) ability to withstand severe conditions of vibration, acceleration and shock. Individually constructed for any standard thermo element.

Write for Bulletin 81-F.

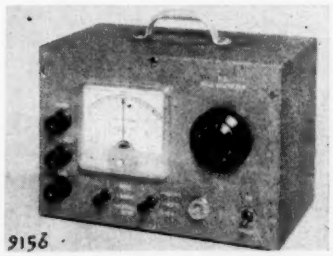
Thermo Electric Co., Inc.
SADDLE BROOK, NEW JERSEY
In Canada — THERMO ELECTRIC (Canada) Ltd., Brampton, Ontario

For more information circle **123** on inquiry card.

NEW INSTRUMENTS

POTENTIOMETER

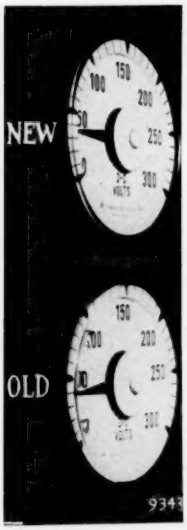
New "Model 301" features a ten-turn slide-wire, is said to have "a higher voltage range than any known



dc null voltmeter on the market." It measures from low voltages, 0-10-v scale, up to 1,000 v; can be used to measure Zener voltage applications, transistor circuits which realize several megohms in some cases, high-impedance circuits, incremental voltages, etc. Accuracy is 0.1% and resolution 0.01%. Null indicator is a 100-0-100 microammeter which can be used for current measurements.—*Paul Industries, P. O. Box* 3474, *Glendale* 1, *Calif.*

For more information circle **303** on inquiry card.

SWITCHBOARD INSTRUMENT



New switchboard instrument, surpassing ASA readability standards by 200%, affords easy reading at better than 120° angles; is particularly useful for utility and mill installations and desirable also for general switchboard service, control panels, etc. Available: voltmeters, ammeters, wattmeters, frequency meters, power-factor meters, varmeters, synchroscopes, temperature indicators and ground detectors. Cover overhang has been eliminated; scale has been moved forward, flush with front of cover bezel; protruding convex-type glass cover provides clearance for scale pointer: tapered pointer tip is in same plane as scale markings. Convex-type anti-static lime glass cover presents a minimum of flat surface and greatly reduces glare from angle lighting. All instruments are thoroughly shielded from external magnetic fields; will stand instantaneous application of ten times the full-scale measured value for one second without mechanical damage. For

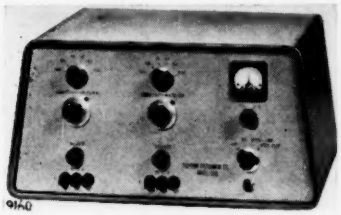
outdoor applications, weather-tight cases, designed on AIEE specs, are sealed and will not condense moisture even under severest weather conditions.—*General Electric Co., Instrument Dept., West Lynn 3, Mass.*

For more information circle **304** on inquiry card.

AMPLIFIERS

HIGH CURRENT DC AMPLIFIER

New "Model D5" high-current tri-purpose amplifier, only amplifier of its type, is designed to drive mirror-



type galvanometers with low-resistance coils, direct-writing galvanometers, and as a lab amplifier. Switching arrangement on front panel makes its versatility instantly available. Frequency response flat to 25 kc, down 4db at 50 kc. Voltage gain 1000; input impedance 10 megohms; output current 100 ma (+ or −).—*Photron Instrument Co.*, 6516 *Detroit Ave., Cleveland, Ohio.*

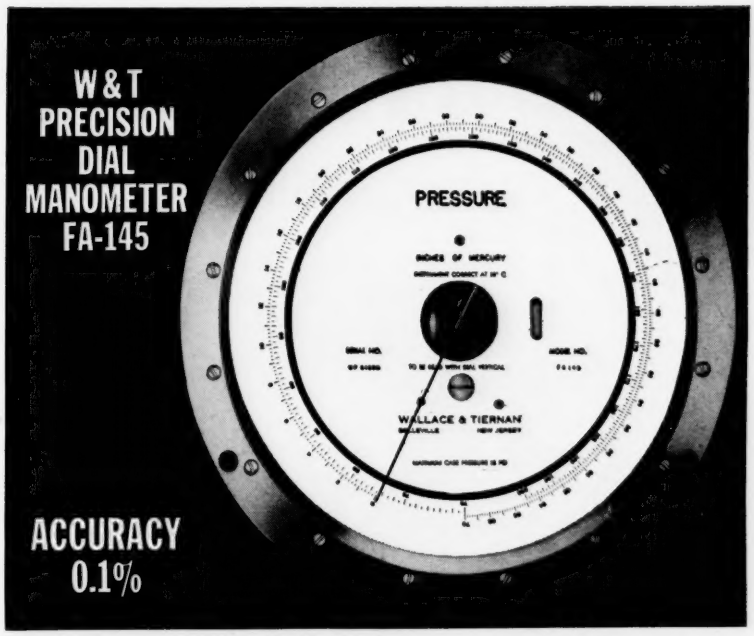
For more information circle **305** on inquiry card.

DC AMPLIFIER PACKAGE

New "System DS" 4-channel galvanometer amplifier package for galvanometer oscillographs includes pow-

er supply as well as bridge balancing and calibrating units for use in wire strain gage and transducer work. Excellent linearity over a wide range of input voltages. Frequency range dc to 5 kc. Balanced input, high output (±60 ma), phase sensitivity, high stability, low noise level, overload indicator, and no operation delay when overloaded. Fine resolution with a 20-step attenuator and a unique gain control which permits full-scale galvanometer deflection for input voltages between adjacent attenuator settings.—*Allegany Instrument Company, Inc.*, 1091 *Wills Mountain, Cumberland, Md.*

For more information circle **306** on inquiry card.



PRECISION PRESSURE Measurement
of Gauge, Vacuum or Differential Pressures on Pneumatic Systems

Accuracy:	1/1000 of full scale
Sensitivity:	1/10,000 in *all* ranges
Ranges:	0 to 120 inches of water (min.) 0 to 300 inches of mercury (max.) Other intermediate ranges available
Scale Length:	45 inch scale in two revolutions
Dial Size:	8½ inches

Write for Publication No. TP-30-A

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CHLORINATORS and CHEMICAL FEEDERS
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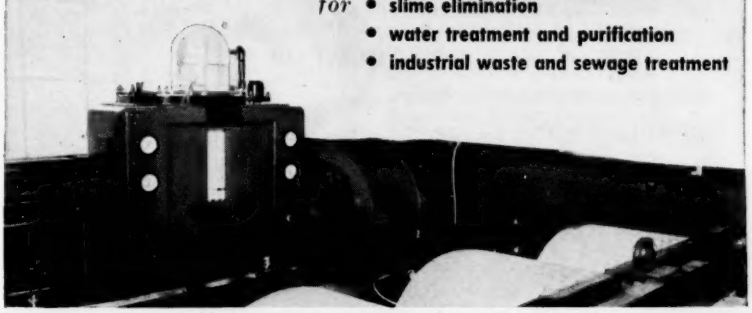

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CD-41 25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

For more information circle **124** on inquiry card.

SIE

MODEL R-1
VOLTMETER

Designed and
Engineered for
DESIGN ENGINEERS

DC VOLTS 1 mv to 1000 v: accurate to 1½% of full scale
AC VOLTS 1 mv to 1000 v: accurate to 3% of full scale
OHMS Zero to 500 megohms: expanded scales

The SIE Model R-1 Voltmeter incorporates Distended DC Scales permitting accurate measurement of voltage changes as small as one part in 10,000. Fully regulated power supply prevents inaccuracies resulting from line transients. D-C amplifier with voltage gain of 200 is flat within ½ db to 100 kc.

Available in bench or rack mounted models.

DRIFT: Less than 3 mv/hr.
TUBE COMPLEMENT: 13
WEIGHT: 34 lbs.

Bench Model $620
Rack Model $700

SIE

SOUTHWESTERN INDUSTRIAL ELECTRONICS COMPANY
P. O. BOX 13058 2831 POST OAK ROAD
HOUSTON 19, TEXAS

For more information circle **125** on inquiry card.

NEW INSTRUMENTS

DC AMPLIFIER FOR PEN-MOTOR RECORDERS

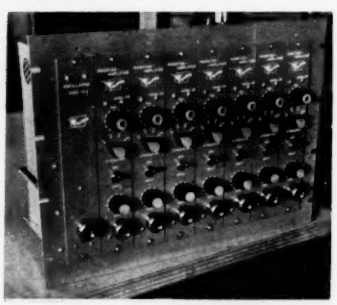
New "Model 405" for use with load and pressure cells, acceleration pickups, thermocouples, strain gages, etc.,

features low drift, a voltage gain of 30,000 and a unique amplification technique which results in high stability without sacrificing long-life characteristics. Power supply is self-contained. Attenuator permits inputs as high as 500 mv without overloading instrument.—*Allegany Instrument Company, Inc.*, 1091 *Wills Mountain, Cumberland, Md.*

For more information circle **307** on inquiry card.

DC AMPLIFIER PACKAGE

New "Model 210" 7-channel dc amplifier package for CRO's and tape recorders, is for use with wire strain



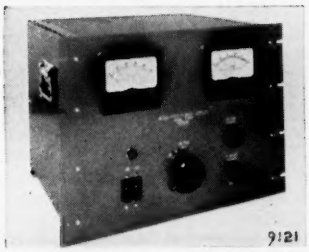
gages, load and pressure cells, acceleration pickups, thermocouples, etc. Unique amplification technique features built-in power supply, insures that signal from phenomenon under study is undisturbed in band-pass frequency. High gain, low drift, frequency response dc to 10 kc, balanced input, and high output impedance.—*Allegany Instrument Co., Inc.*, 1091 *Wills Mountain, Cumberland, Md.*

For more information circle **308** on inquiry card.

POWER SUPPLIES

LAB POWER SUPPLY

New "Model H-3615," for exacting lab and test service, is capable of supplying load currents up to 15 amp



and output voltage range continuously variable from 2 to 36 vdc; 0.5% regulation for combined 105-125 v line variations and 0-15 amp load variations; less than 0.25% ripple. Unique overload voltage feature prevents voltage rise above value set by operator. Unit operates from either 50 or 60 cycle power. Bench or rack mount.—*Deltron, Inc., P. O. Box* 192, *Glenside, Pa.*

For more information circle **309** on inquiry card.

HV DC SUPPLY

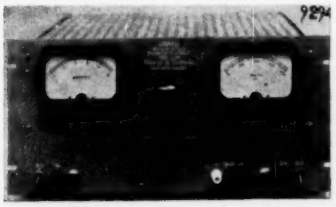
New transistorized supply makes high voltage available from common variety of flashlight batteries: 100

to 3000 v from a 1½ to 6 v source. Basic circuit consists of a free-running pulse generator feeding pulses into primary of a step-up transformer. Secondary voltage of this transformer is rectified with a stable diode. Provisions are made for external control of the output voltage.—*Westronics, Inc.,* 3605 *McCart St., Fort Worth, Texas.*

For more information circle **310** on inquiry card.

MAG-AMP-REG DC SUPPLY

New "Model C 169" tubeless magnetic amplifier controlled dc power supply delivers 0 to 150 v at currents



from 0 to 1½ amp; therefore can often be used where two separate supplies were formerly required. Regulation 1% for line or load, with compensating adjustment control to secure positive or negative impedance, thus giving 0% load regulation. Ripple 0.1% for all line or load conditions. Transient response is better

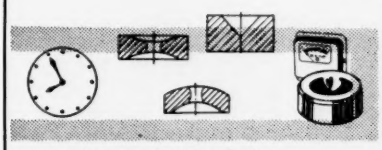
PRECISION

defined by the dictionary

. . . . "the quality or state of being precise; accuracy; mechanical exactness."

defined by an instrument maker . . .

Swiss American



JEWEL BEARINGS

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FEATURE
- exact tolerances
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- low friction coefficient

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ONE OF THE LARGEST FACTORIES OF ITS KIND IN THE WORLD

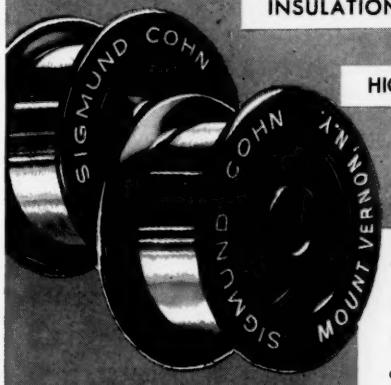
For more information circle **126** on inquiry card.

Anodized Aluminum Wire

INSULATION AT 800°F.

HIGH DIELECTRIC COATING

.0008" TO .030" DIAM.



To fill a need for high temperature insulation in a high conductivity wire. Precision drawn to close resistance control in the smaller sizes.

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SINCE 1901

Specialists in the Unusual

SIGMUND COHN CORP. 121 So. Columbus Avenue • Mount Vernon, N.Y.

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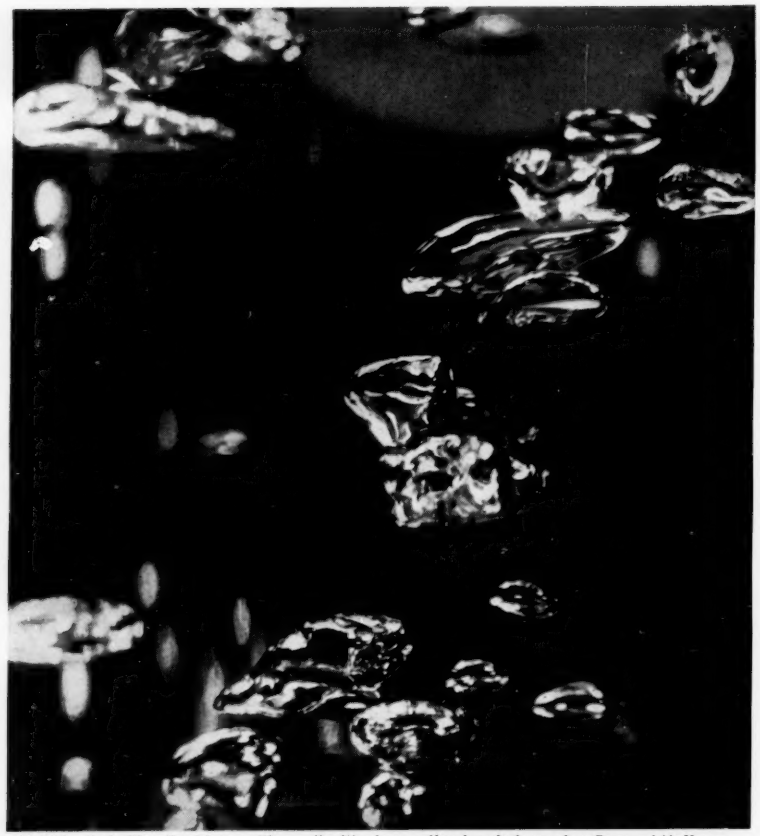

Bubbles in boiling liquid were "frozen" with stop motion by photographer Bernard Hoffman.

Controlling Temperature in Fluid Engineering

Heat is generally only one part of your problem. Pressure, abrasion or corrosion factors usually must be taken into account, too. So if your past experience offers no precedent, you can look to S. Morgan Smith's specialized engineering leadership for assistance.

A number of materials are available to meet extreme working conditions. Here the broad SMS background combines with specialized valve engineering to help you. Perhaps R-S Butterfly Valves can be applied to control volume and flow at high temperatures. Or, if heat and corrosion make extremely accurate timing and fast, drop-tight closure a tough problem, an SMS Rotovalve could be the answer. Whatever your special processing needs, you can get help in protecting your equipment investment.

There is a full SMS line – standard R-S Butterfly Valves ready for fast assembly and shipment from stock, Rotovalves and Ball Valves. A call to our nearest representative will bring information. Or, write S. Morgan Smith, York, Pa., for data on standard valves or special applications.

S. MORGAN SMITH HYDRODYNAMICS

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Rotovalves • Ball Valves • R-S Butterfly Valves • Free-Discharge Valves • Liquid Heaters • Pumps • Hydraulic Turbines & Accessories

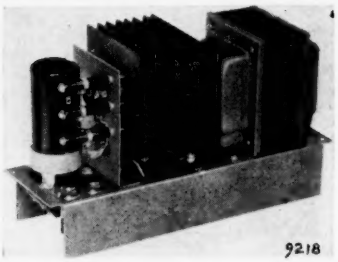
For more information circle **128** on inquiry card.

than 0.2 sec. Input range 105 to 125 vac 60 cps.—*Universal Electronics Co., 1720 22nd St., Santa Monica, Calif.*

For more information circle **311** on inquiry card.

MAG AMP REG SUPPLY

New "Model 28-5MXR" 28-vdc 5-amp power supply features magnetic-amplifier circuitry for dependability



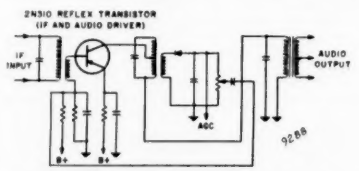
and long life. Regulation for 28 vdc @ 5 amp is 0.25 vdc change NL to FL or line voltage change of 105-125 vac. Ripple and internal noise below 2.5 vac rms. Sub-chassis mounting makes unit suitable for lab and production testing, or for inclusion in original equipment.—*Dressen-Barnes Corp., 250 N. Vinedo Ave., Pasadena, Calif.*

For more information circle **312** on inquiry card.

ELECTRONIC COMPONENTS

GROWN-DIFFUSED REFLEX TRANSISTOR

New "Type 2N310" grown-diffused transistor designed for use as both last IF and audio driver stage in a



reflex configuration permits radio manufacturers to completely eliminate a separate audio driver transistor from their circuits and build transistorized radios with one less transistor.—*Semiconductor-Components Div., Texas Instruments Inc., Box 7124, Dallas 9, Texas.*

For more information circle **313** on inquiry card.

SELENIUM RECTIFIERS

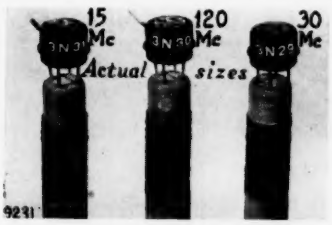
New "HCD Petti-Sel" Siemens-process selenium rectifiers feature high-current-density plates which

make possible smaller rectifiers for a given load with less complex power cell assemblies and increased effiicency over a longer life. It is said that "The new product is unbeatable on a cost-per-ampere basis."—*Radio Receptor Co., Inc.*, 240 *Wythe Ave., Brooklyn* 11, *N. Y.*

For more information circle **314** on inquiry card.

HF TRANSISTOR TETRODES

Three new high-frequency germanium transistor tetrodes, produced by maker's new meltback process, ex-



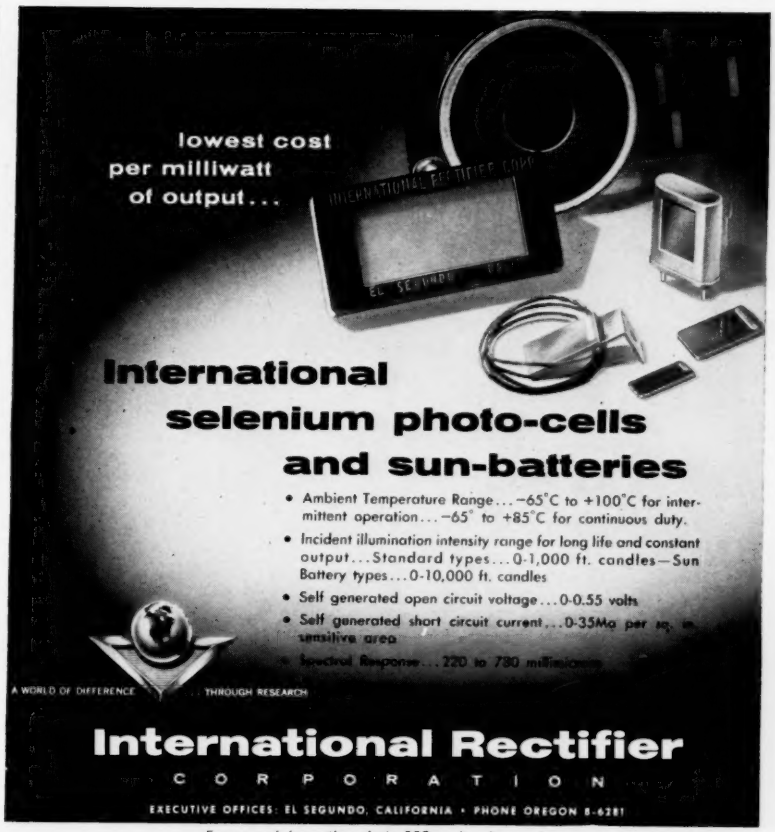
tend applications for transistors into equipment now limited to vacuum tubes: TV sets, radar, two-way radio transmitters and receivers, etc. One is designed to amplify a 120 Mc signal—highest frequency yet attainable in a mass-produced transistor. Max collector dissipation 50 mw at 25°C; rated for 85°C max junction temp. Allowable collector voltage 7. For receiver local oscillator use, "3N29" has an oscillating frequency of 50-60 Mc; "3N30" over 200 Mc, and "3N31" 30 to 40 Mc.—*General Electric Co., Semiconductor Products, Electronics Park, Syracuse, N. Y.*

For more information circle **315** on inquiry card.

20-KW INDUSTRIAL TRIODE

New "Type 6800" RF power amplifier and oscillator triode, for heavy-duty industrial service in induction and dielectric heating, etc., will deliver over 20 kw at frequencies up to 30 Mc; has a heavy-wall anode with high heat capacity, capable of absorbing intermittent overloads; costs much less than communications-type tubes of similar power capability. —*Amperex Electronic Corp.*, 230 *Duffy Ave., Hicksville, L. I., N. Y.*

For more information circle **316** on inquiry card.


lowest cost
per milliwatt
of output...
International
selenium photo-cells
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• Ambient Temperature Range...−65°C to +100°C for intermittent operation...−65° to +85°C for continuous duty.
• Incident illumination intensity range for long life and constant output...Standard types...0-1,000 ft. candles—Sun Battery types...0-10,000 ft. candles
• Self generated open circuit voltage...0-0.55 volts
• Self generated short circuit current...0-35Ma per sq. in. sensitive area
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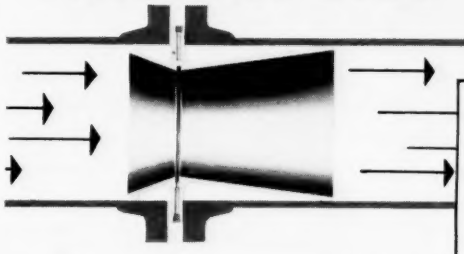
For more information circle **129** on inquiry card.

NEW TYPE FLOW METER CUTS PRESSURE LOSS BY 93.5%*



***Here's How!**

Builders Dall Tube #12D in 12" pipeline — max. differential 80" — max. flow 3900 GPM. — Pressure loss at max. flow—2" of water

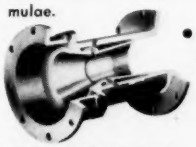
Orifice plate in 12" pipeline for same max. differential and flow — Pressure loss at max. flow—31" of water

Pressure loss saving with Dall Flow Tube — 93.5%

(On one installation, this saving produced pumping power cost reduction of $560.00 each year.)

Get low cost flow metering with **Builders Dall Flow Tubes** — the primary element with the lowest pressure loss of any velocity-increasing differential producer!

- Greater instrument accuracy through higher differentials at the lowest total head loss.
- Fabricated design allows wide construction material choice to meet exact process specifications.
- All critical surfaces precisely machined to Dall formulae.
- *Enduring accuracy* through self-scouring, durable construction.

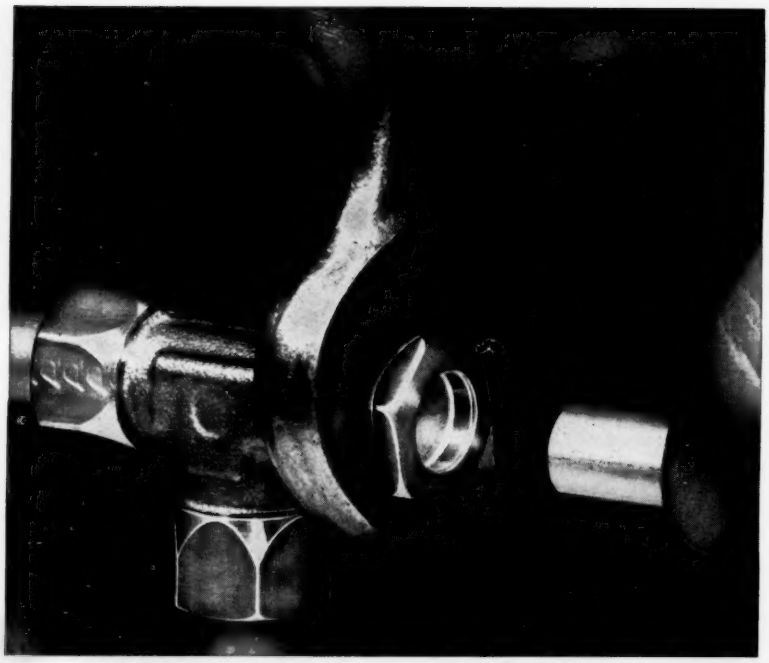


CAST DALL FLOW TUBE RECOMMENDED FOR WATER WORKS AND SEWAGE INSTALLATIONS

Request Bulletin 115-DM1, from **Builders-Providence, Inc., 422 Harris Avenue, Providence 1, R. I.**

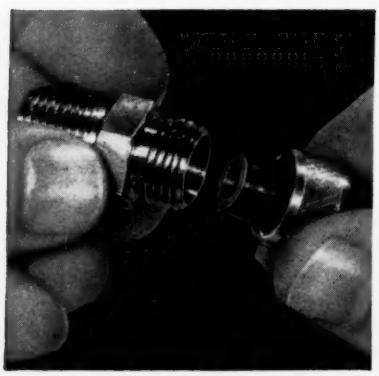
BUILDERS-PROVIDENCE
DIVISION OF
B-I-F INDUSTRIES
METERS FEEDERS CONTROLS

For more information circle **130** on inquiry card.

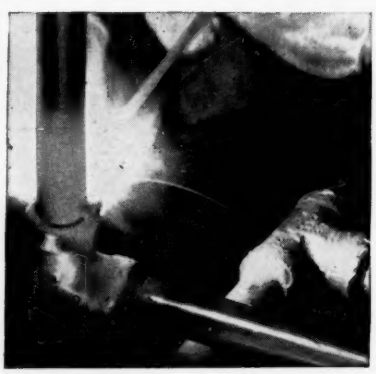


Simply push, then tighten! Anyone can quickly install all-new, *lightweight Intru-lok* tube fittings . . . the proven Parker 3-piece flareless design. Just insert the tube, then tighten the nut with a regular wrench . . . for a leakproof, vibration-proof joint. Made of brass for copper or nylon tubing. Send for complete details in Catalog 4324.

Introducing easy-to-use
PARKER INTRU-LOK



For soft plastic tubing you use knurled nut and expander insert with new *Intru-lok* body. Joints can be disconnected and reassembled. Complete details in Catalog 4324. Send for it.



Weld-lok fittings, for extreme temperatures, corrosion conditions . . . machined from high-quality steel or stainless bar stock and forgings . . . for tubing ¼" through 2" O.D.

TUBE AND HOSE FITTINGS DIVISION
Section 415-K
The Parker Appliance Company • 17325 Euclid Ave., Cleveland 12, Ohio

Parker
Hydraulic and fluid system components

For more information circle **131** on inquiry card.

NEW INSTRUMENTS

MISSILE ARMING SOLENOID

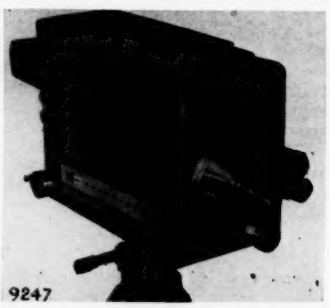
New arming solenoid that operates unpressurized to high altitudes has been fully qualified to 80,000 ft and tested successfully to 115,000 ft. Weighing 11 oz, it has a normal power drain of 0.7 amp and operates down to 18v. Operating temperature range is −65°F to 250°F. Designed specifically to arm missiles in a high-performance fighter, it can be adapted to other applications.—*Fairchild Engine & Airplane Corp., Stratos Div., Manhattan Beach, Calif.*

For more information circle **317** on inquiry card.

MISCELLANEOUS

TV CAMERA

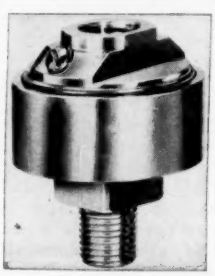
New "Model ASC-7 vidicon" camera for broadcast studio applications features a 7" electronic viewfinder



and a 4-lens turret; unit permits operator to direct and focus image on Vidican pickup tube by extracting a portion of video signal from Vidicon preamplifier and presenting it on the 7" picture tube facing rear of camera housing.—*Kin Tel (formerly Kay Lab), 5725 Kearny Villa Road, San Diego 11, Calif.*

For more information circle **318** on inquiry card.

DIAPHRAGM ASSEMBLY



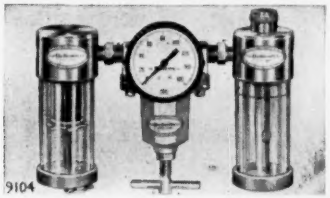
New "Type DA" aluminum diaphragm assembly, for use with nitrogen solutions and other fluids not injurious to aluminum, is designed for field assembly; can be used with any reliable fluid-filled pressure gage in applications up to 200 psi. Housing is aluminum; diaphragm is Buna-N. A plastic tube

of filling fluid and instructions come with every unit.—*Jas. P. Marsh Corp., Skokie, Illinois.*

For more information circle **319** on inquiry card.

AIR-LINE FILTER-LUBRICATOR

New "Lubri-Air Controls" filter and lubricate compressed air. Twin baffle plates whirl incoming air, forcing

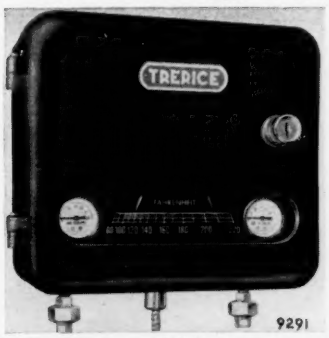


water and dirt particles to base of the plastic reservoir.—*The Bellows Co., Akron 9, Ohio.*

For more information circle **320** on inquiry card.

TEMPERATURE CONTROLLER

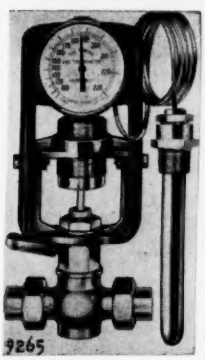
New mercury-actuated air-operated indicating temperature controller is available in two basic types: (1) on-



off fixed high sensitivity, (2) proportional band; can be changed from direct to reverse acting or vice-versa without tools. Standard ranges to 800°F. Also available in a recording model.—*H. O. Trerice Co.*, 1420 *West Lafayette Blvd., Detroit* 16, *Mich.*

For more information circle **321** on inquiry card.

INDICATING SELF-OPERATING TEMPERATURE REGULATOR

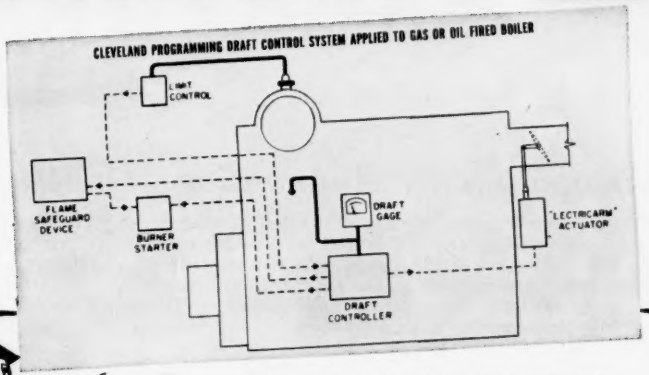


New "No. 11" regulator features a unique front-mounted 4" dial thermometer which provides continuous temperature readings of the process under control. Thermometer being mounted in front instead of on top, regulator can be installed in tight spaces. Available in various control ranges between limits of −60°F and 260°F.—*Powers Regulator Co.*, 3434 *Oakton St., Skokie, Ill.*

For more information circle **322** on inquiry card.

Free DATA ON COMBUSTION AUTOMATION SYSTEM NO. 2 OF A SERIES

CONTROLS



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HOW TO PLAN AND SPECIFY THE CONTROL SYSTEM BEST FOR YOU

Schematically diagrammed and easy to understand, this FREE Manual is No. 2 of a series designed to enable you to solve your combustion control problems. Tells how to select the proper controls to automatically maintain top combustion efficiency and safety under all firing and load conditions.

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COMBUSTION CONTROL SYSTEMS
INDICATING INSTRUMENTS
AIR SAFETY SWITCHES
PANEL CONTROL CABINETS

For more information circle **132** on inquiry card.

For the engineer who wants a 360° view—

Automatic Checkout Equipment

Every phase of AUTONETICS' work in this field keeps you in constant touch with all aspects of control system development. Special openings now for top-level engineers to develop digital computer-type circuits...logic circuits, digital comparators, Analog-to-Digital and Digital-to-Analog converters, high-gain feedback amplifiers, etc. Key positions also open for *systems engineers* to analyze, evaluate, and synthesize automatic checkout methods for fire, flight and guidance control systems. Further details on request. Write: Mr. A. N. Benning, Administrative & Professional Personnel, Dept. 358 IA-6, 9150 E. Imperial Highway, Downey, California.

Autonetics
A DIVISION OF NORTH AMERICAN AVIATION, INC.
AUTOMATIC CONTROLS MAN HAS NEVER BUILT BEFORE

INSTRUMENTS and AUTOMATION Briefs

For this literature circle number on inquiry card.

Syncopation by Automation

The operator inspires "Datatron" by first keying in a 10-digit random number. This causes the machine to generate and store 1,000 single digits, each representing one of the eight diatonic notes in the scale with the two allowable accidentals. The program then motivates "Datatron" to pick successive notes at random, testing each for

TIME VALUE	PRINTED AS	RANDOM NUMBER	NOTES	PRINTED AS
	NO SYMBOL	0	MID. C#	C*
		1	MID. C	C
	*	2	D	D
	**	3	E	E
	***	4	F	F
	8	5	G	G
		6	A	A
/		7	B	B
		8	C above	C:
		9	F#	F*

"PUSHBUTTON BERTHA" as DATATRON wrote it.

/C/F* D A/G 8 C:8 C: F* G/C* A F8 G8/G***/D E F* G/A B C: B8 C:8/C:* B8 C:8/D* C/F* D A/G8 C:8 C: F* G/C* A F8 G8/G***/D E F* G/A B C: B8 C:8/C:* A*/F***/A** C8 C D/F E*/B** C:8 E F*/G***/

melodic acceptability as it goes along. Finished melodies are automatically typed out as a series of letter values and rhythm symbols (see illustration) . . . (*From August, 1956 issue of "Data from ElectroData," ElectroData Division of Burroughs Corp., 460 Sierra Madre Villa, Pasadena, Calif.*)

For this literature circle **401** on inquiry card.

Automatic Xerography

Xerography is a dry, electrostatic copying method producing direct, positive prints of extremely high quality. In the "Copyflow" unit the xerograph process is continuous and automatic, incorporating all necessary steps into one complete cycle.

1. Surface of specially coated drum is charged automatically with positive charge as drum rotates. (2) Image from microfilm or original document is projected upon charged drum forming a pattern of electrostatically charged and discharged areas corresponding to the original image. (3) Latent electrostatic image is developed by cascading oppositely charged powder across drum. Charged powder adheres to the image. (4) Negatively charged powder image is transferred from drum by placing positive charge on the paper. (5) Image is fused permanently to paper by passing under enclosed heating grid. Copy is of highest quality and is completely permanent . . . (*From new 6-page Bulletin X266, The Haloid Co., Rochester 3, N. Y.*)

For this literature circle **402** on inquiry card.

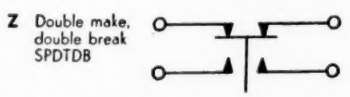
Relay Terms

These Relay Terms are taken from "Definitions on Relay Terms," as published by the National Association of Relay Manufacturers.

Air Gap—A term for Contact Separation or for Magnetic Air Gap.

Ampere-Turns—The product of the number of turns in an electromagnetic coil and the r.m.s. current in amperes passing through the coil.

Armature—The hinged or pivoted moving part of the magnetic circuit of an electromagnetic relay. Sometimes used in a general sense to mean any moving part which actuates contacts in response to a change in coil current.

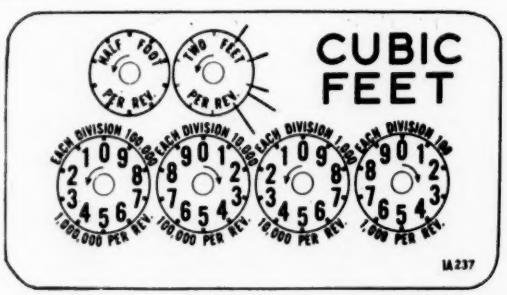


Blow-Out Magnet—A permanent magnet or an electromagnet located in such a position as to place a magnetic field in the space where an electric circuit is to be broken. This field causes the arc to be displaced, thus lengthening it and helping to extinguish it more rapidly. (*From new 20-page booklet "Relays Terms," Automatic Electric Co., 1833 Van Buren St., Chicago 7, Ill.*)

For this literature circle **403** on inquiry card.

Porcelain Enamel

Porcelain Enameling is the fusing, at red heat, of an inorganic glass material to the surface of a metal until the glass is bonded to the metal. This should not be confused with the terms "enamel" or "baked-on-enamel" as applied to the type of finish on automobiles, metal desks, etc., as these enamels are high gloss organic materials suspended or dissolved in volatile solvents, and NOT inorganic minerals (in the form of glass) suspended in water . . .



This gas meter dial shows the finely detailed work that can be reproduced in porcelain enamel. Once the design is fused, it cannot be obliterated by heat, corrosion, abrasion or weathering and it will not fade. Cleaning requires only a damp cloth . . . refinishing is eliminated. (*From new 20-page Bulletin NE 375-25, The Erie Ceramic Arts Co., Dept. IA, 3120 West 22nd St., Erie, Pa.*)

For this literature circle **404** on inquiry card.

How to simplify control problems

Keep systems flexible, carry small inventory, cut maintenance cost with the **Bailey Building Block Method** of instrumentation and control.

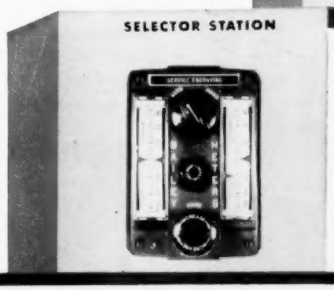
What is the Bailey Building Block Method? It's using standardized Bailey measuring, transmitting, and controlling components and combining them into any system you need. Components can be added as needed . . . removed and reused elsewhere . . . recombined into another system when the need changes. It's flexibility plus!

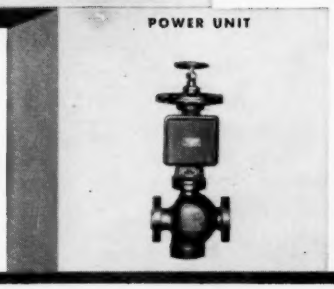
It's all based on the simple fact that a Bailey instrument or control component doesn't care if the measured variable is steam flow, tank level, or tower temperature, to pick just three examples. System components—transmitters, receivers, relays, selector stations, power units—are standardized for multi-purpose use.

A spare component can be used in any one of many systems. Gone are delays waiting for shipments of special parts. Gone are large inventories of spares and parts. Simplified is the training of men for maintenance.

There are many exclusive features and advantages of the individual components used in the Bailey Building Block Method. And there's much more to the Building Block story itself.

For further details, call our local district office or write us at Cleveland. Our engineers will be glad to prove how the Building Block approach will save you money and simplify your instrument and control problems.





G36-1

BAILEY METER COMPANY
1041 IVANHOE ROAD, CLEVELAND 10, OHIO
In Canada—Bailey Meter Company Limited, Montreal

BAILEY BUILDING BLOCK METHOD

RESULTS IN: FLEXIBILITY, SIMPLICITY, ECONOMY

BAILEY METERS

For more information circle **133** on inquiry card.

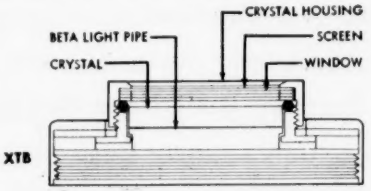
new SCHERR
TOOLMAKERS MICROSCOPE
WITH INTERCHANGEABLE DIAL TEMPLETS AND OCULARS
Reading Angles in Minutes
Thread Templets for U. S. National Thread Profiles-6-80 Pitch. Radii Templets, etc.
LARGE MICROMETER DRUMS READ DIRECTLY IN .0001"
Measuring Range 2" x 1-1/2" and other sizes
A moderately priced PRECISION MEASURING TOOL for Toolroom and Inspection
WRITE FOR CATALOG—Code YGIIQ
GEORGE SCHERR CO., Inc.
COMPLETE LINE OF PRECISION INSTRUMENTS
200-MQ LAFAYETTE STREET • NEW YORK 12, N.Y.
For more information circle 134 on inquiry card.

Briefs—CONTINUED

Scintillation Detector

The models DS5-6 Alpha and DS-7 Beta Scintillation Detectors consist of the DS5 basic probe, the AX7S adapter, and either an alpha phosphor or beta crystal.

The XTA *alpha crystal* consists of a tightly packed, carefully prepared layer of alpha-sensitive ZnS-Ag phosphors approximately 5 mg/cm² thick mounted on a lucite disc and covered by a light-tight double aluminized Mylar film with a density of 0.9 mg/cm² . . . may be used in full illumination, and is completely insensitive to beta or



gamma radiation. The over-all alpha efficiency of the detector is 32% with the protective grid and 50% with the grid removed. Collection efficiency, compensating for geometry and absorption, is greater than 95%. Background count is only a few counts per hour. The plateau is 250 volts with a slope of less than 2% per 100 volts.

The XTB *beta crystal* consists of a $\frac{3}{16}$" x 1½" dia. anthracence crystal optically coupled to a thin lucite support and mounted in a housing assembly similar to that used with the phosphor. It is sensitive to beta radiations with energies as low as 60 kev. Counting efficiency is virtually 100% for betas which penetrate the thin foil. The unit is insensitive to alpha radiation, and has a gamma efficiency of less than 5% when used with a quarter-volt scaler or ratemeter. Background is approxi-

DEVELCO SALT SPRAY
FOG TEST CHAMBER
To Meet MIL-E-5272A and others
TOP OPENING
FRONT OPENING
WALK-IN
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DEVELCO
DEVELOPMENT ENGINEERING COMPANY
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For more information circle 135 on inquiry card.

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ELECTRONIC SCALES
Tank scales
Hopper scales
Crane scales
R.R. Track scales
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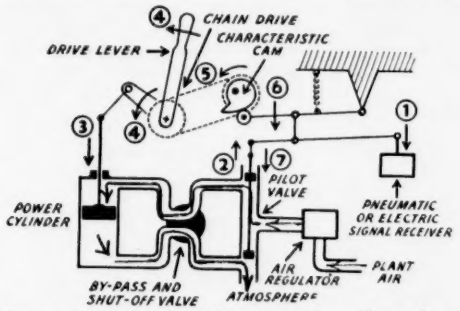
One of the leading steel companies weighs its heavy pipes quickly and accurately. 5, 10, 15 tons of metal weighed and recorded on tape or cards by the Ametron Electronic Scale.
New low costs, improved models. Write for free Ametron Brochure 8.
THE STANDARD OF ACCURACY SINCE 1888
STREETER-AMET COMPANY
GRAYSLAKE, ILLINOIS
For more information circle 136 on inquiry card.

mately 150 counts per minute unshielded and 50 cpm when used in the Models 3052 or 3054 shields. Average plateau is 150 volts with less than 5% slope per 100 volts. (*From new 64-page Catalog Q, Nuclear-Chicago Corp., 223 West Erie St., Chicago 10, Ill.*)

For this literature circle **405** on inquiry card.

Final Drive Unit

The Final Drive Unit is shown schematically. The sequence of its operations in response to a control signal is shown by the motions numbered 1 through 7. It can be



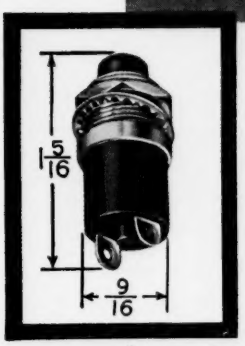
seen that a simple feedback linkage, driven through a chain and sprocket, will close the pilot valve after a definite travel of the power piston. This same linkage operates the pilot valve to oppose forces tending to displace the drive lever.

The lever displacement resulting from a given signal will depend on the shape of the characteristic cam, and this can be varied to suit individual applications . . . (*From new 4-page Catalog 56-3, Republic Flow Meters Co., 2240 Diversey Parkway, Chicago 47, Ill.*)

For this literature circle **406** on inquiry card.

8 AMP. U.L. RATING

. . . ½ amp. size and price



- Positive, audible, snap-action mechanism with double-break contacts.
- Smaller than most ½ amp. *non-snap* switches
- 1-piece silvered terminals and contacts
- Shielded against dust and moisture.
- Types with lugs or 6" wire leads
- Normally-open or normally-closed SP-ST contacts.

Full details in Data Sheet S-4

B-SERIES
Push-Button Switches

HETHERINGTON INC.

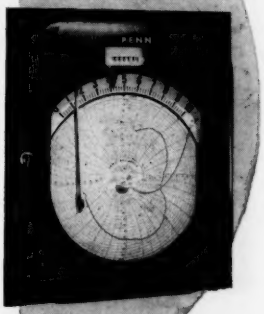
1200 Elmwood Avenue, Sharon Hill, Pa.

For more information circle **137** on inquiry card.

BURGESS-MANNING

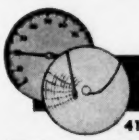
Simple
Rugged
Self-Contained

Filled-Tube System
TEMPERATURE and PRESSURE
Recorder



This completely self-contained, self-actuated recorder is designed to extreme simplicity and features a sturdy, friction-free movement. It requires no adjustment, maintenance or auxiliary power. The inert gas fill of the system is harmless to chemical processing or other applications where mercury and certain vapor tension fills cannot be used. This Burgess-Manning Recorder will give you a new low initial instrument cost combined with long, dependable, maintenance and trouble-free operation. Temperature elements (gas filled) for range of −40° to +800° F. — tubing to 250 ft. Pressure elements available for 0-30 to 0-3000 PSIG.

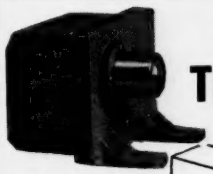
Ask for Bulletin No. 1021



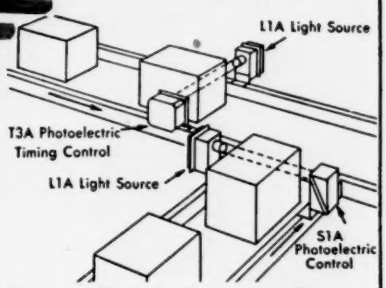
BURGESS-MANNING COMPANY
PENN INSTRUMENTS DIVISION
4120 Haverford Ave., Philadelphia 4, Pennsylvania

Instrumentation and Controls for water, steam, gases, sewage and industrial wastes

For more information circle **138** on inquiry card.



Photoelectric Timing Controls



For conveyor jam-up and traffic control, ramp signals, paint spray control, counting and other applications where timing is needed with photoelectric operation.

The diagram shows application of Autotron Photoelectric Timing Control and Photoelectric Control on converging conveyors to prevent collision or jamming of cartons.

AUTOTRON Photoelectric Timing Controls are available with varied timing arrangements and adjustable timing periods to meet widely varied requirements.

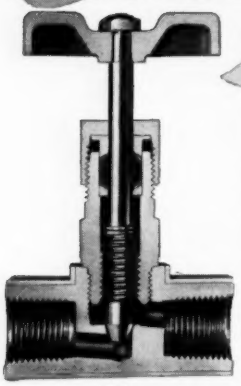
Send for catalog with application diagrams or tell us what you want to do.

The AUTOTRON Co.
P.O. Box 722-QV, Danville, Ill.

Representatives in principal cities

For more information circle **139** on inquiry card.

Now... the Marsh Needle Valve in 416 Stainless Steel throughout!



All the superior dependability of the Marsh Needle Valve . . . with all the corrosion resistance and durability of 416 Stainless Steel! Guaranteed for working pressure up to 10,000 psi; equally efficient at any lower pressure. Globe and angle patterns with double female connections in ⅛" to 1" size range. Also globe and angle valves with male inlet, female outlet, ¼" and ½" sizes.

For complete details, write for Bulletin No. NV-2.

MARSH INSTRUMENT CO.
Sales Affiliate of Jas. P. Marsh Corp.
Dept. 42, Skokie, Illinois

MARSH
"THE STANDARD OF ACCURACY"

Marsh Instrument & Valve Co. (Can.) Ltd., 8407 103rd St., Edmonton, Alta., Can.
For more information circle 140 on inquiry card.

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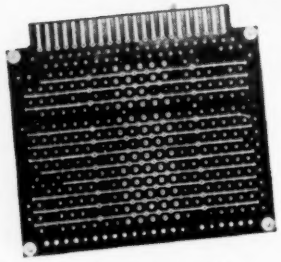
100 HOLES P. M.
WITH NEW HERMES Engravograph

for printed circuit plates

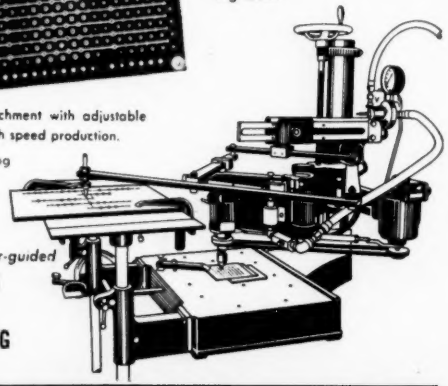


• Pantograph reproduces drill pattern from template in any reduction ratio – assuring high accuracy.

• Allows drilling and routing of different size holes in one operation without changing tools.

Pneumatic attachment with adjustable feed gives high speed production.

Ask for catalog XP-1



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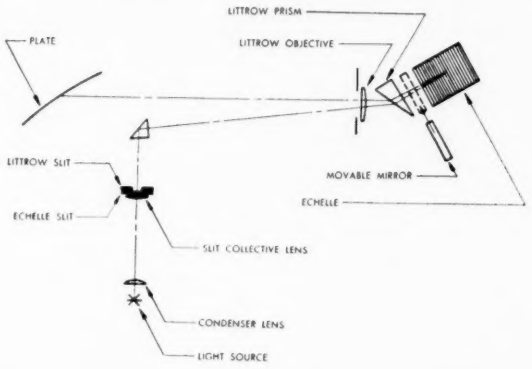
Briefs—CONTINUED

Littrow-Echelle Spectrograph

To accomplish the widest range of work, in the smallest space, with the greatest possible speed and accuracy, the Littrow-Echelle is the consummate tool. This dual-purpose instrument is virtually two spectrographs in one compact



unit. It is a complete Littrow Prism Spectrograph which converts, at the flip of a switch, to an Echelle model. Either conventional spectrograms or echellograms are quickly produced.

Radiation, collimated by the objective, is first dispersed in the plane of the optical axis by the 30° prism and then falls on the echelle, which reflects it back through the prism after dispersing it in a plane perpendicular to that

Check and calibrate any type of thermocouple-actuated temperature instrument with one portable Pyrotest

Read temperatures or millivolts directly . . . without graphs, charts or conversion tables

The only portable potentiometer pyrometer with interchangeable direct reading scales

Pyrotest is 9 instruments in one, with 6 standard scales for thermocouples; 3 standard scales for millivolt readings. Special scales for any desired reading or use. Scales interchangeable in 30 seconds. Compact, rugged, easy to carry—12 lbs.; 12" x 9" x 8½". Accurate to 1/6 of 1%. Self-contained power supply. Write for new bulletin 9B.

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INDIANAPOLIS 25, IND.

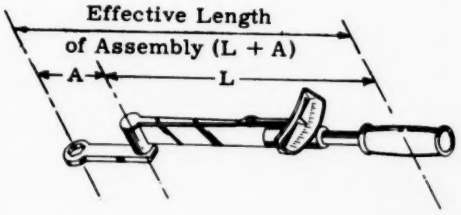
For more information circle 141 on inquiry card.

of the optical axis. A mirror is located between the prism and the echelle in such a manner that it can be rotated into the beam by the small synchronous motor. This excludes the echelle from the optical path and permits the photography of conventional Littrow prism spectra . . . (*From new 32-page Catalog D-277, Bausch & Lomb Optical Co., Rochester 2, N. Y.*)

For this literature circle **407** on inquiry card.

Torque-Wrench Range Change

It is easy to see that a simple adapter, which can even be made from a regular socket handle, would permit making two torque wrenches out of one. It permits purchasing the less expensive and more versatile of two possible choices of torque wrenches, and the one that will be the fastest and easiest to use on the job . . . .



A simple formula . . . allows proper selection of the size or lever length of an adapter and a suitable torque wrench: $A = (T_s - T_w)(L)/T_w$, where A = Length of Adapter. T_s = Torque exerted at the end of the adapter. T_w = Wrench scale reading. L = Lever length of torque wrench. (*From new 6-page Bulletin, P. A. Sturtevant Co., Addison, Ill.*)

For this literature circle **408** on inquiry card.

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Wilder MICRO-PROJECTOR with VERTICAL LIGHT BEAM

New model long range measuring stage 1" x 4" reading to .0005".

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Full set of lenses between 10X and 100X magnifications.

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Completely versatile. Available as a basic unit for production inspection or as a completely equipped contour measuring projector.

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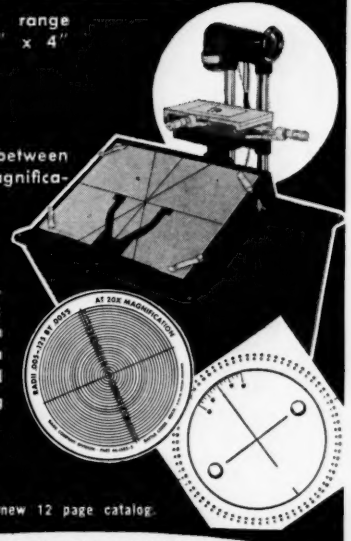

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For more information circle **143** on inquiry card.

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ALL PURPOSE LABORATORY TIMERS

MODELS AT $23.95 TO $29.95

You can set the large 8" dial for any desired time period within an unusually wide range of 3600 possible settings, (ie., 1 sec. to 60 min., 1 min. to 60 hrs., etc.). At end of preset interval, alarm sounds and external load is automatically switched on or off.

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For more information circle **142** on inquiry card.

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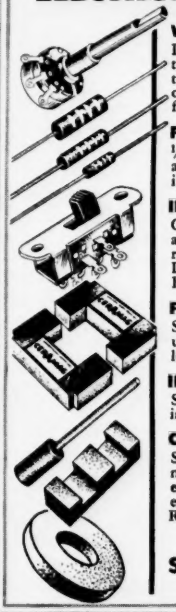

VARIABLE RESISTORS (Controls)
Dozens of standard composition-element types including single and dual concentric shafts and midgets for transistorized circuits. Choice of 9 switch types. Write for Bulletin RC-10B.

FIXED RESISTORS
½-, 1- and 2-watt composition types in all standard RETMA ranges. Packaged in strips, stacked layers or reels.

INEXPENSIVE SLIDE SWITCHES
Over 15 low-cost types for instruments, appliances, electrical toys, TV's and radios, record players, etc. AC and/or DC ratings from 0.5 to 15.0 amperes. Bulletin RC-10D.

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Stackpole Ceramag cores offer maximum uniformity in high permeability, low-loss types. Bulletin RC-9A.

IRON CORES
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CERAMIC PERMANENT MAGNETS
Stackpole Ceramagnet permanent magnets offer greater permanence, high electrical resistivity and fully usable energy without "keepers." Bulletin RC-10A.

Electronics Components Division
STACKPOLE CARBON CO.,
St. Marys, Pa.

For more information circle **144** on inquiry card.

Staggered starting of electric motors...

AGASTAT

Time / Delay / Relay

AGASTAT allows you to stagger the starting of three motors without imposing their load on the line at the same time.

The AGASTAT is

- **electrically actuated, pneumatically timed.**
- **light, versatile, dependable.**
- **instantaneous recycling.**
- **adjustable in timing from 0.1 second to more than 10 minutes.**
- **available in AC or DC models which offer delays on energizing and de-energizing, manually-actuated time delay switch, remote push button control, hermetically-sealed units.**

Write our application engineers for help with your timing problem. Address Dept. A25-69

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GERMANIUM
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INDOX
MELAMINE FIBER GLASS
MICA, SYNTHETIC
POTASSIUM BROMIDE
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*QUARTZ, CRYSTAL
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**SAPPHIRE
**SODIUM CHLORIDE
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STRONTIUM TITINATE
TITANIUM DIOXIDE
*VYCOR
*X-RAY LEAD GLASS
ALL TYPES KNOWN GLASS

*Carried in stock
**Purchased for orders

For more information circle **146** on inquiry card.

Mechanical Spring Design

Spring materials are employed in large variety as to kind, shape and size. The great majority of springs are made of carbon steels ranging in analysis from about 0.50% to 1.20% carbon. These materials may be fabricated in any one of a number of conditions: hot-rolled, cold-rolled or drawn, annealed, hard-drawn, tempered, or patented . . . .

Table of Formulas for Round and Square Wire

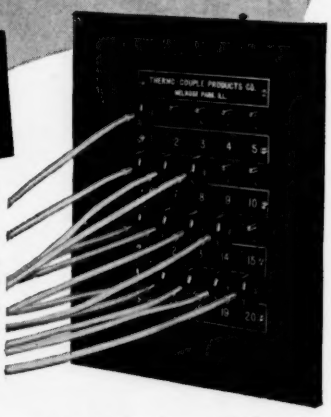
	Round	Square		Round	Square
P	$\frac{\pi S d^3}{8D}$	$\frac{S d^3}{2.4D}$	S	$\frac{8PD}{\pi d^3}$	$\frac{2.4PD}{d^3}$
P	$\frac{Gfd^4}{8D^3}$	$\frac{Gfd^4}{5.58D^3}$	S	$\frac{fGd}{\pi D^2}$	$\frac{fGd}{2.4D^2}$
f	$\frac{\pi S D^2}{Gd}$	$\frac{2.4SD^2}{Gd}$	d	$\frac{\pi D^2 S}{Gf}$	$\frac{2.4SD^2}{Gf}$
f	$\frac{8PD^3}{Gd^4}$	$\frac{5.58D^3P}{Gd^4}$	d	$\sqrt[3]{\frac{8PD}{\pi S}}$	$\sqrt[3]{\frac{2.4PD}{S}}$
$\frac{P}{f}$	$\frac{Gd^4}{8D^3N}$	$\frac{Gd^4}{5.58D^3N}$	W	$\frac{Gd^4}{8D^3N}$	$\frac{Gd^4}{5.58D^3N}$

S = Stress. G = Torsional modulus of elasticity. f = Deflection per coil. W = Pounds per inch deflection. N = Number of active coils. D = Mean diameter of spring. d = Diameter of wire. P = Load carried.

All spring design is founded on Hooke's law, which states that within the proportional limit, otherwise known as the elastic limit, of any material, deflection is directly proportional to load . . . Compression springs stress the wire in torsion. The basic formula for stress in torsion for round wire is: $S = \frac{Mc}{J}$ in which M = torsional mo-

for time-saving convenience

20 MINIATURE THERMOCOUPLE CONNECTORS in 1



6"x 8" PANEL!

This standard 20 connector panel offers quick connection for all phases of temperature measuring applications ...Aircraft, Automotive, Research Laboratory, test cells, etc.

Constructed of ⅛" anodized black aluminum, 5½" x 7½" plus ½" mounting flange. Positive contact is sure and simple—just solder Thermocouple leads into pre-tinned contact pins. Contacts accommodate wire gauges to and including 14 B&S Ga. Available in Iron Constantan, Chromel Alumel* and Copper Constantan.

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Panels Can Be Constructed to Meet Your Specifications. . . . Any Number of Connectors to Meet Your Needs.

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For more information circle **147** on inquiry card.

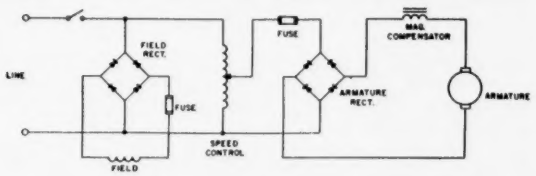
ment = PR = $\frac{PD}{2}$ if D is the mean diameter in a coil spring; c = distance from neutral axis at center of section. Since maximum stress is at outside, for a wire diameter d, c = $\frac{d}{2}$; J = polar moment of inertia. For a round section this value is $\frac{\pi d^4}{32}$ . . . (*From new 84-page "Handbook of Mechanical Spring Design," Associated Spring Corp., Bristol, Conn.*)

For this literature circle **409** on inquiry card.

Variable Speed Drives

Magne-Speed "Junior" variable speed drives in small fractional HP sizes from ⅛ to 1/100 HP, feature dynamic braking and reversing.

Type: Non-electronic. Horsepower Ratings: ⅛ and 1/15 HP. Power Supply: 115 volts ±10%; 50/60 cycles. Speed Range: Approx. 40:1. Regulation: Approx. 5% of Base Speed; curves available on request. Range of Speed Adjustment: Zero to full speed. Base Speed: 8000 rpm. Speed

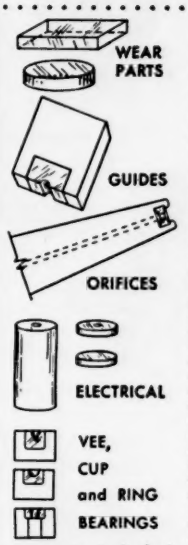


of Response: Instantaneous. Ambient Temperature: 32°F to 110°F (0°C to 43°C) . . . (*From new 4-page Bulletin S-790, Magnetic Amplifiers, Inc., 632 Tinton Ave., New York 55, N. Y.*)

For this literature circle **410** on inquiry card.

For more information circle **148** on inquiry card.

can Sapphire solve your wear or bearing problems?



If you need a surface that is absolutely free from "grain." If you need extreme hardness, high dielectric strength, resistance to heat and corrosion, then Sapphire could be the answer.

Sapphire can be cut, ground, polished, flame-formed and bonded to other materials.

But even after more than 50 years of specializing in only the tough, industrial jewel jobs, we can't tell you that Sapphire is the answer to your problems unless we see your blueprints and specifications.

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For more information circle **149** on inquiry card.

cleaned and back at work in 5 minutes

Waukee FLO-METER

The Waukee FLO-METER can be cleaned and back in operation in five minutes *or less!* Saves time and money.

Inherent accuracy of the FLO-METER is protected by Waukee's design for fast, easy cleaning. No tools are needed. Production interruption at a minimum.

The Waukee FLO-METER also features: built-in Control Valves, panel mounting, simple piping, large 6" and 9" scales for ease of reading. Capacities 3 CFH to 10,000 CFH.

Complete information in Bulletin 203. Write for it. **Waukee Engineering Company,** 5137 North 35th Street, Milwaukee 9, Wisconsin.

For measuring: air — ammonia — dissociated ammonia — argon — butane — city gas — endothermic cracked — exothermic cracked — forming gas — helium — hydrogen — natural gas — nitrogen — oxygen — propane.

Waukee FLO-METERS • AIR-GAS MIXORS
INDUSTRIAL WASHING MACHINES

For more information circle **150** on inquiry card.

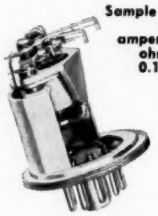
VHS* RELAY

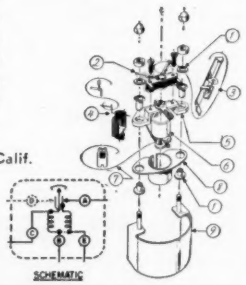
(*Very High Sensitivity)

● The VHS is a balanced armature, Alnico magnet type relay. It is internally shock-mounted and resistant to vibration. The screw-on cover is gasket sealed. It can be opened and resealed.
Connections: 9 pin octal style. Dimensions: 1¾ diameter x 2¼ long. Weight: 4 ounces. Sensitivity: Infinite variations from 0.2 Ua. to 10 Amp. or 0.1 Mv. to 500 volts, self contained. Higher volts or amps with external multipliers. A.C. rectifier types. Trip point accuracies to 1%. Differential 1%. The degree of resistance to shock and vibration primarily depends upon sensitivity and type of action wanted. In general, the relays will not be permanently damaged by shocks of 100 G's and vibrations up to 2,000 cps at 3-4 G's. The most sensitive relays may close their contacts under these conditions. Contacts: SPST or SPDT, 5-25 Ma. D.C. Other ratings to ½ Amp. A.C. A locking coil gives high pressure and chatter free contact even under shock and vibration. Prices on the order of $20-$80. Delivery 4 to 6 weeks. Assembly Products, Inc., Chesterland 10, Ohio.
West Coast: P. O. Box XX, Palm Springs 10, Calif.

Model 266

Sample specs. are: 0.2 micro-amperes, (12,000 ohms coil) or, 0.1 millivolts, (5 ohms.)





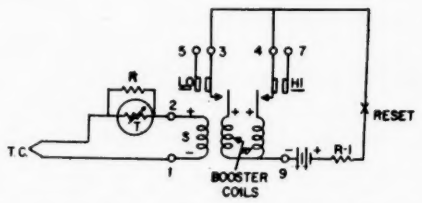
1. Shock mount
2. Contact assemby
3. Contact detail
4. Armature with contact detail
5. Cast bracket
6. Alnico magnet
7. Bearing detail
8. Yoke (steel)
9. Mounting frame

For more information circle **151** on inquiry card.

Briefs—CONTINUED

VHS Relay

The VHS (Very High Sensivity) Relay has a moving coil armature which rotates in the flux gap of an Alnico magnet. The moving element is similar to voltmeters and microammeters. It rotates on polished pivots in vee cup jewels. The 'pointer' is a contact of solid Iridium-Platinum alloy.



A locking coil, integral with the moving element (it is wound on the moving coil) develops additional torque to drive the contacts together with considerable pressure.

Contact Travel may be short (.015") for high speed, or it may be as much as ½" for time delay or more accurate trip setting.

Sensitivity: Infinite variations from 0.2 micro-ampere to 10 amperes or 0.1 millivolt to 500 volts. Higher volts and ampere ratings with external multipliers (shunts, series resistor, etc.).

Fig. 16 shows temperature alarm with thermocouple sensing element, thermistor compensation, high and low limits, double locking coils, double heavy duty contacts. (*From new 12-page Bulletin* 104, *Assembly Products, Inc., Chesterland 9, Ohio.*)

For this literature circle **411** on inquiry card.

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showing how

CROWN
HYDRA-TROL
Remote Control

- Has positive stroke in both directions.
- Does not depend on spring return or outside power sources.
- Immediate synchronization of system in either direction.
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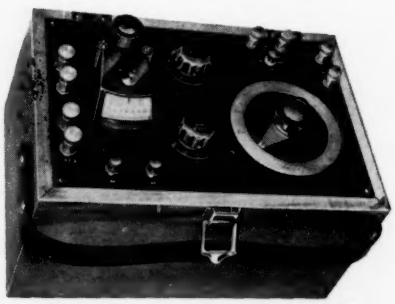
For more information circle **152** on inquiry card.



E-3272

A PORTABLE KELVIN BRIDGE

For checking resistance of shunts, switch contacts, bus bars or other low resistance.

Range, 0.5 Micro-Ohms to 22 Ohms

Completely self-contained, with sensitive galvanometer & batteries

Accuracy, 0.25% from .0005 to 5 ohms
0.5 % from .0001 to .0005 ohms

Other Portable & Laboratory Models

Also Wheatstone Bridges, Resistance Boxes, Laboratory & Portable Potentiometers

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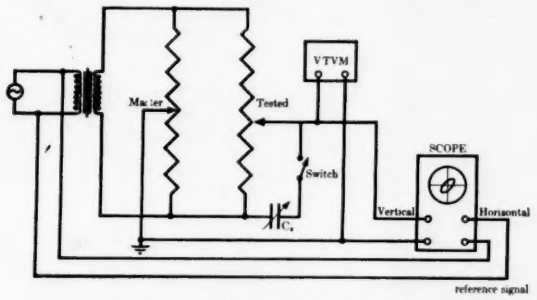
PHILADELPHIA 44, PA.

For more information circle **153** on inquiry card.

Phase Shift in Pots

To verify experimentally the equations for phase shift and to rate the various Helipot models in regard to quadrature voltage, methods were developed for measuring phase shift, quadrature voltage, and resistance-wire-to-mandrel distributed capacitance . . . The actual circuitry used to measure the inphase and quadrature error is shown.



For the master potentiometer in the bridge, a 250-ohm carbon potentiometer was chosen because of its almost pure resistive characteristics up to 10,000 cps (although in these experiments 1,000 cps was the highest frequency used). The transformer was for isolation of the reference signal from the test circuit.

One important factor in the circuit is the location of the grounding point in the bridge. The slider of the master potentiometer was grounded, rather than that of the tested potentiometer, to prevent the lead capacitance of the tested potentiometer from loading the relatively high impedance of the tested potentiometer and causing a false bridge balance. (*From new 30-page Technical Paper 552, Helipot Corp., Newport Beach, Calif.*)

For this literature circle **412** on inquiry card.

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By MOSER JEWEL COMPANY, pioneer industrial jewel manufacturer for over 50 years.

- HIGHLY POLISHED STEEL PIVOTS AND STAFFS
- HARD ALLOY WELDED TIPS
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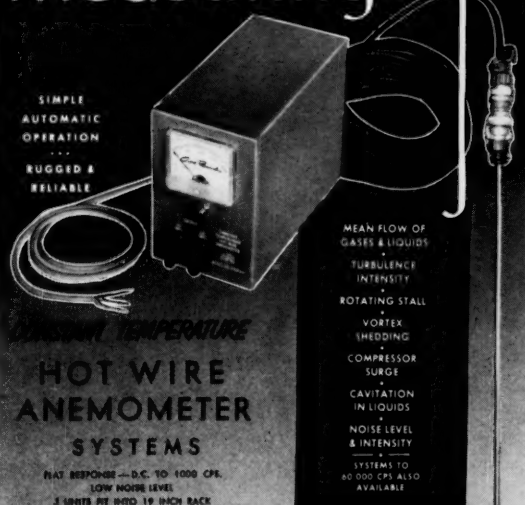
For more information circle **155** on inquiry card.

for accurate measuring of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MEAN FLOW OF GASES & LIQUIDS
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ROTATING STALL
VORTEX SHEDDING
COMPRESSOR SURGE
CAVITATION IN LIQUIDS
NOISE LEVEL & INTENSITY
SYSTEMS TO 60 000 CPS ALSO AVAILABLE

HOT WIRE ANEMOMETER SYSTEMS

FLAT RESPONSE—D.C. TO 1000 CPS. LOW NOISE LEVEL 3 UNITS FIT INTO 19 INCH RACK

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For more information circle **154** on inquiry card.

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Reg. U. S. Pat. Office

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★ **EASY - TO - READ**—broad — flat stripe — mercury column in a yellow stem

★ **ECONOMICAL**—replacement can be inserted on-the-job without difficulty

★ **ARMOUR PROTECTED**—to resist corrosion and dirt

★ **TWO TYPES**—angle and straight stem

ASICO Reg. U. S. Pat. Off.

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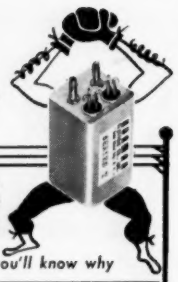
For more information circle **156** on inquiry card.

the leading contender in the sensitive relay class!



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Compare it and you'll know why

- ★ .975" x .975" x 1¾" high
- ★ Up to —2 amp. 28V. DC, 115V AC
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- ★ Coil Resist. up to 20,000 ohms
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The latest addition to a line of miniature hermetically sealed sensitive relays, the new Kurman Series "T", weighing only 3½ oz., is now available—the mighty midget of the sensitive class. Radically different in design, you will find the Series "T" to be superior in performance — economically priced with excellent delivery service.

Why not specify the Series "T" for your next sensitive relay application and check its performance for yourself? Write to Dept. IA for detailed specification sheet.

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PRESET COUNTER
By **FREED**

The Freed Model 2020 Preset Counter is designed for low cost reliable counting applications, where accuracy and maintenance-free operation is required.

Cold cathode counting and trigger tubes, with simplified circuits, are used throughout which assure years of trouble-free counting service and low-power consumption.

Model 2020 is a 4-digit single preset counter capable of controlling any operation that is repeated up to 9,999 times. Any number from 1 to 9,999 may be preset on the 4-digit selector switches. When the preset total has been reached, the counter will provide an output pulse and close contacts on a relay. These outputs may be used simultaneously or separately to stop machines, actuate control signals, or trigger additional equipment.

SPECIFICATIONS

Maximum Count: Four digits — 9,999
Size: 8 x 6 x 12 inches
Maximum Counting Rate: 300,000 counts per minute
Weight: 11 pounds
Input Sensitivity and Waveform: Not critical
Power: 25 watts 105-125 volts, 50-60 cycles
Outputs: Relay contact 10 Amperes Pulse output 50 volts
Price: $425.00

FREED ALSO MANUFACTURES TOTALIZING, PRESET, AND BATCHING COUNTERS

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INSTRUMENTS and AUTOMATION

New Literature

AUTOMATION

PROCESS CONTROL SYSTEMS. Maker's "ElectroSyn," system which measures and controls pressure, differential pressure, flow, liquid level and temperature by magnetic servo techniques, is discussed in 4-page Bulletin B257.—Norwood Controls, Unit of Detroit Controls Corp., 934 Washington St., Norwood, Mass.
Circle **413** on inquiry card.

METER-RELAYS. Indicating meters with built-in relays for control are covered in new 40-page Catalog 4C.—Assembly Products, Inc., Chesterland, Ohio.
Circle **414** on inquiry card.

RESISTANCE WELDING CONTROL. New 4-page Bulletin GEA-6593 describes non-synchronous resistance welding control.—General Electric, Schenectady 5, N.Y.
Circle **415** on inquiry card.

ANNUNCIATORS. Continuous supervision of control systems and machinery in industrial applications by maker's annunciator is presented in new 19-page booklet.—The Scam Instrument Corp., 1811 W. Irving Park, Chicago 13, Ill.
Circle **416** on inquiry card.

METER-RELAYS. New 16-page Catalog AC-2 describes maker's meter-relay controls for temperature control, torque control, etc.—Tipptronic, Inc., 4th and Franklin Sts., Tipp City, Ohio.
Circle **417** on inquiry card.

MOTORS, SERVOS

TIMING MOTORS. New 2-page Bulletin A.W.H. MO 805 contains information on maker's three basic d-c timing motors.—The A. W. Haydon Co., Waterbury, Conn.
Circle **418** on inquiry card.

MOTORS. New 4-page issue of "Bodine Motorgram" (Vol. 37, No. 2), features article on design of small motors for quiet operation.—Bodine Electric Co., 2254 W. Ohio St., Chicago 12, Ill.
Circle **419** on inquiry card.

WORM MOTOR. New 2-page Bulletin WM 450 discusses features of maker's slow-motion worm motor.—Brevel Products Corp., 601 W. 26 St., New York 1, N. Y.
Circle **420** on inquiry card.

WEATHER-PROTECTED MOTORS for outdoor use, including construction chart, are detailed in new 6-page Bulletin 51 B8606 A.—Allis-Chalmers Mfg. Co., Box 512, Milwaukee, Wis.
Circle **421** on inquiry card.

VALVES

VALVES. Valves for Automation in steel mills and liquid level control are the subject of new 16-page Bulletin SM-1.—Golden Anderson Valve Specialty Co., 1232 Ridge Ave., Pittsburgh 33, Pa.
Circle **422** on inquiry card.

PINCH-TYPE VALVES. Pinch-type and hose-bodied type valves in both standard and new "SuperSeal" metal enclosed designs, are described in new 48-page Catalog FL-1116.—Farris Flexible Valve Corp., 400 Commercial Ave., Palisades Park, N.J.
Circle **423** on inquiry card.

RATIO REGULATOR. Control of the firing of multiple burners by maker's "RRO" oil-air ratio-regulators is detailed in new 4-page Data Sheet 722A.—Hauk Mfg. Co., 124-136 Tenth St., Brooklyn 15, N. Y.
Circle **424** on inquiry card.

SHUT-OFF VALVES. New 2-page Bulletin 8A describes automatic shut-off valves, operative in case of break.—Schutte and Koerting Co., Cornwells Heights, Bucks County, Pa.
Circle **425** on inquiry card.

TEMPERATURE

CONTROLS TEMPERATURE AND PRESSURE. Maker's line of temperature and pressure controls, including self-operating regulators, water mixing equipment, control valves and pneumatic motors, are contained in new 96-page general catalog.—Powers Regulator Co., 3434 Oakton St., Skokie, Ill.
Circle **426** on inquiry card.

TEMPERATURE CONTROLS. Data on maker's electronic controls for heating, ventilating and air conditioning, are covered in new 4-page Bulletin F 2287-4.—Barber-Colman Co., Rockford, Ill.
Circle **427** on inquiry card.

TEMPERATURE MONITORING. Maker's standard sub-assemblies, and temperature monitoring systems are covered in new 8-page Bulletin 72.—Thermo Electric Co., Inc., Rochelle Park P.O., Saddle Brook, N.J.
Circle **428** on inquiry card.

ENVIRONMENTAL CABINETS. Mechanically operated cabinets for tem-

peratures from −225°F to +350°F, are detailed in new 4-page bulletin.—Webber Corp., Box 217, Indianapolis 6, Ind.

Circle **429** on inquiry card.

ELECTRIC THERMOSTATS. Five new 4-page bulletins are available: RT-801 describes Model EA3 (single-pole) for sterilizers, glue pots, etc.—RT-803 through RT806 are double-pole models: RT-801 (Model D1 and D10) is intended for molding machines, heat exchangers, etc.—RT-804 (Model E1) is for refrigerating, ventilating, etc.—RT-805 (Model H1) affords overtemperature protection (single-pole)—RT-806 (Model H14) has features of H1 with double-pole switch.—Robertshaw-Fulton Controls Co., 110 E. Otterman St., Greensburg, Pa.

Circle **430** on inquiry card.

THERMISTORS. Typical applications, circuitry, and specifications for wafer, rod, and bead-type thermistors, are discussed in new 10-page Bulletin T-100.—Thermistor Div., Gulton Industries, Inc., 212 Durham Ave., Metuchen, N. J.

Circle **431** on inquiry card.

BIMETAL THERMOSTATS. Snap-acting Type M bimetal thermostats are described in new 2-page Bulletin 6000.—Stevens Manufacturing Co., Inc., Lexington, Ohio.

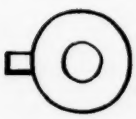
Circle **432** on inquiry card.

RESISTANCE THERMOMETERS. New 4-page Bulletin T56 describes maker's resistance thermometer elements "RdF Stikons."—New 2-page Bulletin describes a new miniature resistance thermometer probe.—Arthur G. Ruge Associates, Inc., 733 Concord Ave., Cambridge 38, Mass.

Circle **433** on inquiry card.

INDUCTION HEATERS. New 12-page Brochure 571 describes maker's line of induction heaters and contract-soldering service.—McDowell Electronics Inc., 117 Woodside Ave., Metuchen, N. J.

Circle **434** on inquiry card.



FLOW, PUMPS

FLOW METERS. Maker's "Ring Balance" meters including applications, are described in new 6-page Bulletin MSP-141.—Hagan Chemicals & Controls, Inc., Pittsburgh 30, Pa.

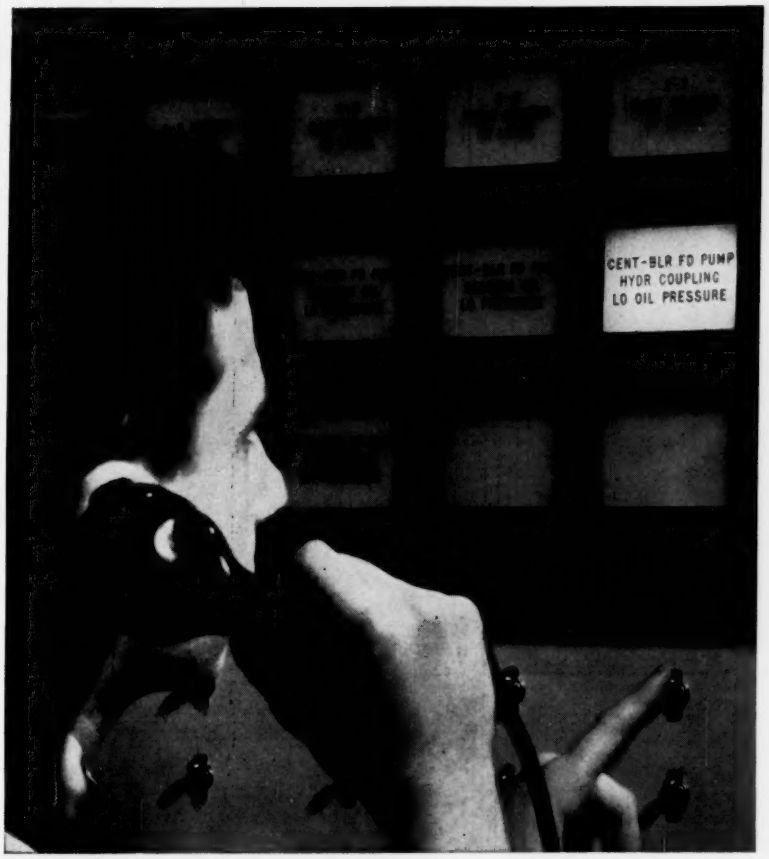
Circle **435** on inquiry card.

LIQUID METERS. Positive-displacement meters and accessories, also installation directions are covered in new 27-page Bulletin 566-11.—Neptune Meter Co., 19 W. 50th St., New York 20, N. Y.

Circle **436** on inquiry card.

CHEMICAL FEEDER. New 2-page Bulletin 1913 provides information on the Proportioneer Model 1913, a new air or water operated diaphragm feeder for concentrated chemicals.—Proportioneers, Inc., Providence 1, R. I.

Circle **437** on inquiry card.



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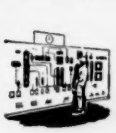
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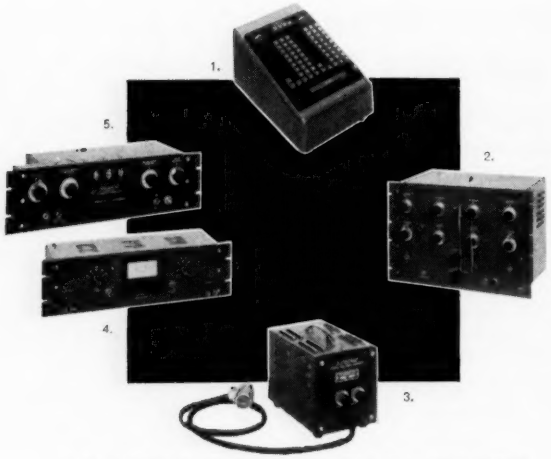

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NEW LITERATURE

BARREL PUMP. New 2-page Bulletin 1256 describes controlled-volume barrel pump for toxic or corrosive chemicals.—Milton Roy Co., 1300 Mermaid Lane, Phila. 18, Pa.

Circle **438** on inquiry card.

PRESSURE, STRAIN

PRESSURE REGULATORS. New 4-page Folder F-15B contains information on filters, regulators, air relief valves, etc.—Watts Regulator Co., Lawrence, Mass.

Circle **439** on inquiry card.

BASIS WEIGHT CONTROL. New 12-page Brochure B-1657 covers "Accu-Ray" Basis Weight Control Systems for the paper industry.—Industrial Nucleonics Corp., 1205 Chesapeake Ave., Columbus 12, Ohio.

Circle **440** on inquiry card.

STRAIN GAGE APPARATUS. Maker's model BL-1516, including standard and optional accessories and specification sheet, is covered in 4-page Catalog Sheet E D 11511.—Brush Electronics Co., 3405 Perkins Ave., Cleveland 14, O.

Circle **441** on inquiry card.

CALIBRATING UNITS. Bridge-balance and calibrating units for direct recording of strain, loads, acceleration, pressure, etc., are covered in new 4-page Bulletin BBU 2-57.—B & F Instruments, Inc., 4732 N. Broad St., Phila. 41, Pa.

Circle **442** on inquiry card.

PIEZOELECTRIC TRANSDUCERS. Basic design and high and low frequency response of acceleration, force, and pressure pickups are discussed in new 12-page manual, "Instructions for the Application of Piezoelectric Transducers."—Endevco Corp., 161 E. California St., Pasadena, Calif.

Circle **443** on inquiry card.

TIME, SPEED

COUNTER, TIMER. Tachometers, rotary transducers, magnetic pickup, frequency counters, interval timers, totalizer, and preset counter are listed and described in new 4-page release.—Dynapar Corp., 5150 Church St., Skokie, Ill.

Circle **444** on inquiry card.

TACHOSCOPE. New 4-page Bulletin describes re-designed line of precision portable chronometric Tachometers and Tachoscopes.—O. Zernickow Co., 15 Park Row, New York 38, N. Y.

Circle **445** on inquiry card.

MOTOR SPEED CONTROLLER. Type SH-10 motor speed controller is covered in new 2-page bulletin. Bohn blowers are described in another new 2-page bulletin; maker's recycling timer, Model BR, is detailed in 2-page bulletin.—Minarik Electric Co., 224 E. 3rd St., Los Angeles 13, Calif.

Circle **446** on inquiry card.

VIBRATION PROTECTOR. "Vibraswitch," a device that protects rotating and reciprocating machinery by anticipating malfunctions, is described in new 4-page Bulletin 600-1.—Fielden Instrument Div., Robertshaw-Fulton Controls Co., 2920 N. 4th St., Phila. 33, Pa.

Circle **447** on inquiry card.

OPTICAL

MICROSCOPES. Maker's new Series R research microscopes, including accessories and price list, are covered in new 20-page Booklet D-1057.—Bausch & Lomb Optical Co., Rochester 2, N. Y.

Circle **448** on inquiry card.

OPTICAL TOOLING EQUIPMENT. New 20-page catalog lists company's line of optical tooling equipment.—Keuffel & Esser Co., Hoboken, N. J.

Circle **449** on inquiry card.

WATER, AIR, STEAM

CHLORINATION. New 2-page reprint article, "How to Calculate Chlorine Cost," compares cost of different forms of chlorine additives.—Wallace & Tiernan Inc., 25 Main St., Belleville 9, N. J.

Circle **450** on inquiry card.

AIR POLLUTION PHOTOMETER. Description of portable optical and electronic system for recording and controlling dust and smoke concentrations is presented in new 8-page Bulletin JM-1000-C.—Phoenix Precision Instrument Co., 3803-05 N. 5th St., Phila. 40, Pa.

Circle **451** on inquiry card.

AIR COMPRESSOR. New 8-page brochure describes features of maker's new two stage, air compressor, "Channel-Flo."—Ingersoll-Rand, 11 Broadway, New York 4, N. Y.

Circle **452** on inquiry card.

WATER TREATING. Selection of processes for medium-pressure boilers is the subject of new 7-page Reprint 111, Index 2.18.—Cochrane Corp., 17th St. below Allegheny Ave., Phila. 32, Pa.

Circle **453** on inquiry card.

DRAFT CONTROLLER. Controller with adjustable proportional band is described in new 4-page Leaflet CFE-28-15-1256.—Cleveland Fuel Equipment Co., 1111 Brookpark Rd., Cleveland 9, O.

Circle **454** on inquiry card.

ANALYTICAL, LABORATORY

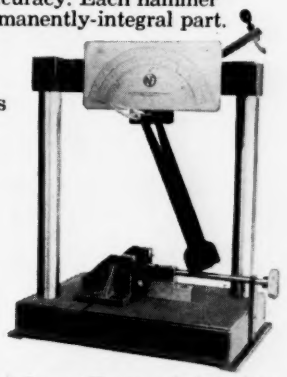
SPECIFIC GRAVITY. New 4-page Bulletin S4 gives data on company's Series 27 Densimeter for correcting volumetric data to gravimetric readout.—Potter Aeronautical Corp., U.S. Route #22, Union City, N. J.

Circle **455** on inquiry card.

LABORATORY EQUIPMENT. Two new 4-page bulletins describe (1) Controlled humidity units and accessories (Bulletin 5525-A); and (2) "Magni Whirl" baths, featuring built-

impact tester

The machine that makes the Izod (cantilever beam) or Charpy (simple beam) test on each of three capacity ranges. Separate hammer for each test in each capacity range (6 hammers in all). Hammers are interchangeable. Individual calibration of each hammer assures accuracy. Each hammer is one welded unit striking bit — a permanently-integral part. Possibility of variable errors due to energy absorption by screwed-on weights and detachable bits is eliminated. Attachment of hammers is at point of suspension minimizing any effect of looseness.



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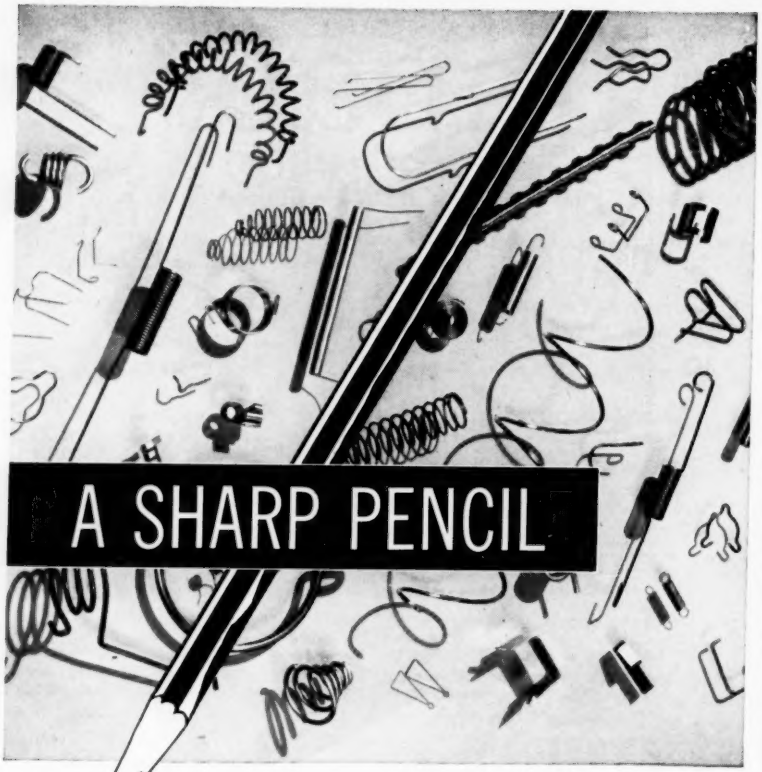

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NEW LITERATURE

in automatic stirring and circulation. (Bulletin 5515-A).—Boder Scientific Co., 810-814 Penn Ave., Pittsburgh 22, Pa.

Circle **456** on inquiry card.

OVENS AND INCUBATORS. New 8-page Bulletin 376-C describes Thelco line of ovens and incubators for laboratory use.—Burrell Corp., 2223 5th Ave., Pittsburgh 19, Pa.

Circle **457** on inquiry card.

LABORATORY EQUIPMENT. Loose-leaf binder contains information on maker's products for spectrometry, counting, health, reactors, counters, etc. Includes price List 22.—Radiation Counter Labs., Inc., 5121 W. Grove St., Nucleonic Park, Skokie, Ill.

Circle **458** on inquiry card.

LABORATORY EQUIPMENT. New 16-page booklet, "What's New for the Laboratory," provides information on new products distributed by company. —Scientific Glass Apparatus Co., Inc., Bloomfield, N. J.

Circle **459** on inquiry card.

GAS CHROMATOGRAPH. New 4-page Bulletin 802 describes maker's Model 220 industrial gas chromatograph.—Beckman Instruments, Inc., Process Instruments Dept., 2500 Fullerton Rd., Fullerton, Calif.

Circle **460** on inquiry card.

VISCOSITY CUP. New 4-page "Newsletter" Vol. 4 No. 20 describes the Gardner No. 4 Ford type viscosity cup and accessories for paints, varnishes, lacquers, oils and other light-bodied materials.—Gardner Lab., Inc., Bethesda 14, Md.

Circle **461** on inquiry card.

SPECTROCHEMICAL ANALYSIS. Specifications of imported arc and spark units and accessories for spectrochemical analysis are covered in new 23-page Brochure CH 402.—Jarrell-Ash Co., 26 Farwell St., Newtonville 60, Mass.

Circle **462** on inquiry card.

DIFFERENTIAL REFRACTOMETERS. Analysis and control of organic and inorganic liquids or gases by measuring refractive index changes are reviewed in 8-page Bulletin R1000.—Phoenix Precision Instrument Co., 3803-05 N. 5th St., Phila. 40, Pa.

Circle **463** on inquiry card.

X-RAY GONIOMETER. Imported instrument for checking plane alignment of cut quartz and other crystals, is described in new 12-page Brochure CH 381/2.—Jarrell-Ash Co., Newtonville, Mass.

Circle **464** on inquiry card.

PULSE ANALYZER. Maker's Model 201, for nuclear research, reactors systems, chemistry, metallurgy, medicine, etc. is described in new 4-page bulletin.—Beva Laboratory, 1640 N. Olden Ave. Ext., Trenton, N. J.

Circle **465** on inquiry card.

NUCLEONICS

RADIATION MONITOR. "Nucliguard," a combination area, personnel and equipment monitor for detecting changes in the radioactivity level is described in new 2-page Bulletin N-57.—Nuclear Measurements Corp., 2460 N. Arlington Ave., Indianapolis 18, Ind.

Circle **466** on inquiry card.

SURVEY METERS. Maker's Models GS-3 and GS-3L; Model GS-3W; Models GS-3 and GS-3L; Model SS-2, for detecting radioactivity are covered in new 4-page Bulletin GS-57.— Nuclear Measurements Corp., 2460 N. Arlington Ave., Indianapolis 18, Ind.

Circle **467** on inquiry card.

RADIATION PROTECTION. New 4-page bulletin (A.I.A.F:le37-E) describes radiation protection material for X-ray and radioisotope applications.—Ameray Corp., Route 46, Kenvil, N. J.

Circle **468** on inquiry card.

COMPUTING, DATA HANDLING

AUTOMATIC WAVE ANALYZER. Direct reduction of analog data by maker's Analyzer is the subject of new 4-page Bulletin 9001.—Davies Labs. Div., Minneapolis-Honeywell Reg. Co., Davies Labs. Div., 10721 Hanna St., Beltsville, Md.

Circle **469** on inquiry card.

SERVOMULTIPLIERS. A discussion of servomultiplier performance is featured in first issue of 10-page company journal, "Berkeley Engineering."—Beckman/Berkeley Div., 2200 Wright Ave., Richmond, Calif.

Circle **470** on inquiry card.

ANALOG COMPUTER. Maker's new "Ease"-1132, is the subject of new 4-page bulletin.—Beckman/Berkeley Div., 2200 Wright Ave., Richmond, Calif.

Circle **471** on inquiry card.

DIGITAL COMPUTER. Maker's "Transac S-2000," using transistors and printed wiring, is described in new 10-page booklet.—Philco Corp., Government & Industrial Div., 4700 Wissahickon Ave., Phila. 44, Pa.

Circle **472** on inquiry card.

NUMERIC DISPLAYS. Maker's "In-Line" units, which feature enlarged numbers and/or characters in a single plane are described in new 2-page Bulletin ILD-1.—Industrial Electronic Engineers, 3973 Lankershim Blvd., N. Hollywood, Calif.

Circle **473** on inquiry card.

DIGITAL RECORDER. Model 560 A with analog output for automatic data plotting, is discussed in new 4-page "Hewlett-Packard Journal," vol. 8, no. 7.—Hewlett-Packard Co., 275 Page Mill Rd., Palo Alto, Calif.

Circle **474** on inquiry card.

CARD-PROGRAMMED FUNCTION GENERATOR. Model 160 diode function generator, featuring automatic card programming, is described in

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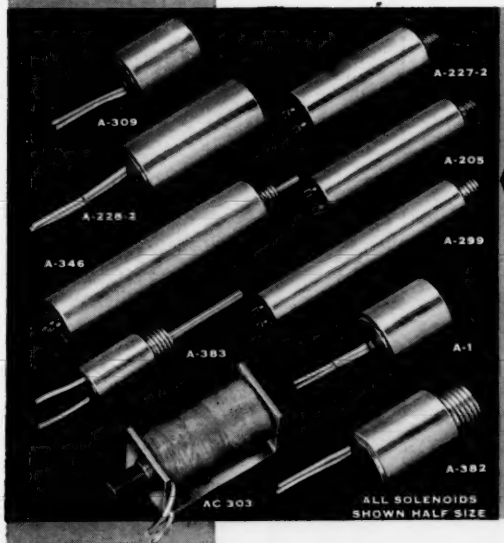

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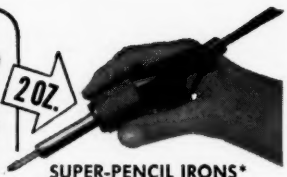

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NEW LITERATURE

new 2-page leaflet.—Stephen-Douglas Co., Inc., 1650 21 St., Santa Monica, Calif.

Circle **475** on inquiry card.

RECORDERS

ELECTROLYSIS RECORDER. Model 1VB621, a portable millivoltmeter recorder for electrolysis surveys, is covered in new 4-page Bulletin E 1117.—The Bristol Co., Waterbury 20, Conn.

Circle **476** on inquiry card.

OSCILLOGRAPHS. Maker's line of multi-channel rack mounting oscillographs, amplifiers, and related supplies, are detailed in new 8-page folder.—Brush Electronics Co., Div. of Clevite Corp., 3405 Perkins Ave., Cleveland 14, O.

Circle **477** on inquiry card.

RECORDERS. New 8-page Catalog Section 35 provides information on E-A KVA and KVAR recorders; 12-page catalog 33-56 covers electrodynamometer-type wattmeters; 4-page Bulletin 357 covers applications in welding, sintering furnaces, etc.—The Esterline-Angus Co., Inc., P. O. Box 596, Indianapolis 6, Ind.

Circle **478** on inquiry card.

CHART PRINTER. New 4-page folder illustrates and describes maker's "Identichart" devices for printing identifying marks on strip charts.—Royson Engineering Co., Hatboro, Pa.

Circle **479** on inquiry card.

TAPE RECORDERS. Business and industrial applications of tape recorders are discussed in new 40-page pocket size booklet.—Minnesota Mining and Mfg. Co., St. Paul 6, Minn.

Circle **480** on inquiry card.

TESTING, GAGING, INSPECTION

TEST EQUIPMENT. Portable meters for servicing television and radio; industrial equipment; heating and cooling equipment; and appliances is described in new 6-page Bulletin 2058.—Simpson Electric Co., 5200 W. Kinzie St., Chicago 44, Ill.

Circle **481** on inquiry card.

PENETRANT TESTING. New 16-page manual on "Zyglo" and "Zyglo-Pentrex," discusses fluorescent penetrant materials and nondestructive testing techniques.—Magnaflux Corp., 7300 W. Lawrence Ave., Chicago 31, Ill.

Circle **482** on inquiry card.

COMPARATORS. New 20-page Circular 601 describes "Electrolimit" external and internal comparators.—Pratt & Whitney Co., Inc., Charter Oak Blvd., West Hartford 1, Conn.

Circle **483** on inquiry card.

HARDNESS TESTING MACHINE. Production Brinell-hardness tests are described in new 4-page Bulletin A-15.—Gries Industries, Inc., Testing Machine Div., New Rochelle, N.Y.

Circle **484** on inquiry card.

BENCH-TYPE HYPOT. Testing of plastics and other insulating materials with maker's Model 4300 is covered in 2-page data sheet.—Associated Research Inc., 3758 W. Belmont Ave., Chicago 18, Ill.

Circle **485** on inquiry card.

MARKING DEVICES. Maker's steel stamps, holders, and fixtures for the inspection department are covered in new 4-page Bulletin SS-120.—M. E. Cunningham Co., 1025 Chateau St., Pittsburgh 33, Pa.

Circle **486** on inquiry card.

COMPARATOR GAGE. Maker's model "L," which works on the back-pressure circuit principle, is detailed in new 4-page bulletin.—Freeland Gauge Co., 9940 Freeland Ave., Detroit 27, Mich.

Circle **487** on inquiry card.

ROD DIAMETER GAUGE. New 4-page pamphlet describes maker's infra-ray non-contact gauge for hot rod diameters of wire rod and other hot rolled shapes.—Industrial Gauges Corp., West Englewood, N. J.

Circle **488** on inquiry card.

HEIGHT GAGE. New 6-page folder describes the Webber Optical Height Gage for measuring heights up to 61" with accuracies of ±.000005" per inch of height.—Webber Gage Co., 12900 Triskett Rd., Cleveland 11, Ohio.

Circle **489** on inquiry card.

SURFACE ROUGHNESS. New 2-page Bulletin LT 131 describes new "Profilometer" type LC tracer, for surface roughness measurements in holes.—Micrometrical Mfg. Co., 345 S. Main St., Ann Arbor, Mich.

Circle **490** on inquiry card.

MEASURING COMPARATOR. New 4-page bulletin describes company's measuring comparator Model 100.—Paul M. McPherson Precision Instruments, Acton, Mass.

Circle **491** on inquiry card.

PIPING, TUBING, FITTINGS

HOSE FITTINGS. How to attach reusable hose fittings, is the subject of 2-page Bulletin 4433B1.—Tube & Hose Fittings Div., Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, O.

Circle **492** on inquiry card.

TUBE FITTINGS. Brass fittings, drain and shut-off cocks, push-pull-control components, etc., are covered in new 48-page Catalog 6073.—The Weatherhead Co., Ft. Wayne, Ind.

Circle **493** on inquiry card.

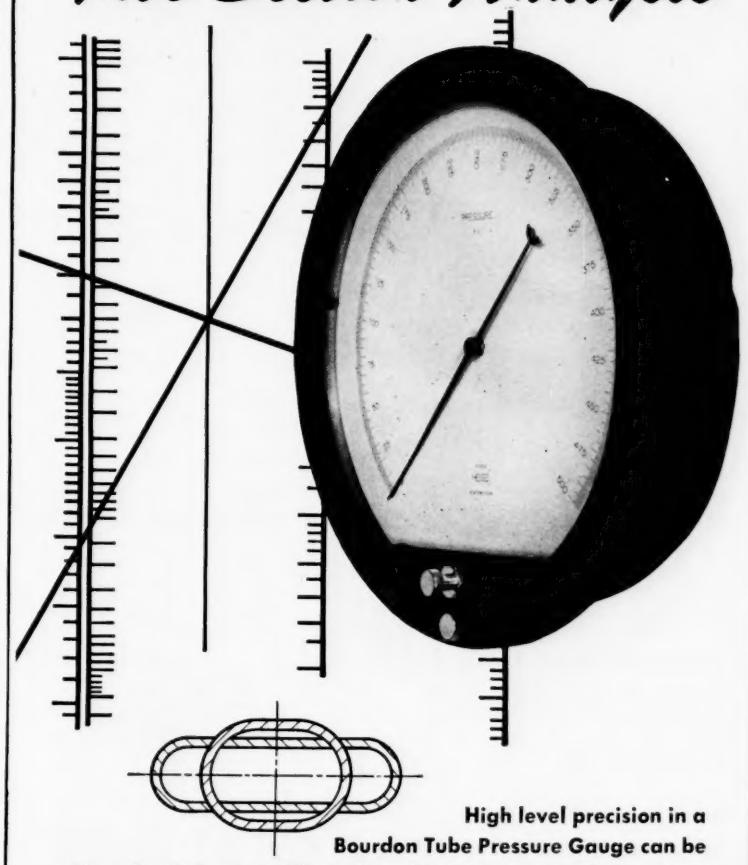
HOSE AND HOSE ENDS. Information on industrial hose, assemblies, swivel adapters, etc., is covered in new 40-page catalog.—The Weatherhead Co., Fort Wayne, Ind.

Circle **494** on inquiry card.

PIPE. New 4-page folder provides data on maker's seamless and welded

HEISE GAUGES

Tube Section Analysis



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NEW LITERATURE

pipe in carbon, alloy and stainless steel.—The Babcock & Wilcox Co., Tubular Products Div., Beaver Falls, Pa.

Circle **495** on inquiry card.

TUBING. New 12-page bulletin, TDC 185, gives data on maker's seamless titanium pipe and tubing.—The Babcock & Wilcox Co., Tubular Products Div., Beaver Falls, Pa.

Circle **496** on inquiry card.

QUICK-DISCONNECT COUPLING. Maker's new "HK" coupling suitable for fuming acids, alkali, solvents, high pressure steam, etc., is described in new 2-page Bulletin 270.—Snap-tite, Inc., Union City, Penna.

Circle **497** on inquiry card.

PIPE MARKERS. New 8-page Catalog 2157 describes printed self-adhesive vinyl plastic pipe, cable and wire markers.—Printed Cellophane Tape Co., 521 North LaBrea, Los Angeles 36, Calif.

Circle **498** on inquiry card.

CHEMICAL FAUCET. New 2-page leaflet describes maker's stainless steel faucet for dispensing flammable and corrosive fluids.—Economy Faucet Co., 12 New York Ave., Newark 1, N. J.

Circle **499** on inquiry card.

ELECTRICAL, ELECTRONIC INSTRUMENTS

TUBE TESTER. New 8-page booklet describes maker's tube testing machine model 123A.—The Hickok Electrical Instr. Co., 10514 Dupont Ave., Cleveland 8, O.

Circle **500** on inquiry card.

TUBE TESTER. Maker's new model 123A automatic, cardmatic tube testing machine, is the subject of new 7-page bulletin.—The Hickok Electrical Instr. Co., 10514 Dupont Ave., Cleveland 8, O.

Circle **501** on inquiry card.

TEST INSTRUMENTS. New 8-page catalog lists telemetering test instruments, wave form and spectrum analyzers, etc.—Panoramic Radio Products, Inc., 10 South Second Ave., Mount Vernon, N. Y.

Circle **502** on inquiry card.

TRANSISTOR TESTER. New 2-page bulletin describes maker's model TT-2, a tester for basic characteristics of transistors.—Kit-Tronics, 2315 Hendola Dr. NE, Albuquerque, N.M.

Circle **503** on inquiry card.

SIGNAL DELAY GENERATOR. Maker's Model 100A, a single channel, single output signal delay generator is the subject of new 2-page bulletin.—Datascan, Inc., 48 Notch Rd., Little Falls, N. J.

Circle **504** on inquiry card.

METAL DETECTOR. Claimed to penetrate seven feet through sand, silt, mud, and any type of non-metallic medium, underwater metal detector is described in new 22-page Booklet 3547.—Gardner Electronics Co., Phoenix, Ariz.

Circle **505** on inquiry card.

POSITIONING INDICATOR. "Torsynator," a positioning indicator and remote positioning power drive, is discussed in new 4-page data sheets.—Air Marine Motors, Inc., Amityville, N. Y.

Circle **506** on inquiry card.

VOLTMETERS. Maker's Models 101 and 101-50, with accuracies of ±0.25%, are described in new 2-page bulletin.—Beckman/Shasta Div., Box 296, Station A, Richmond, Calif.

Circle **507** on inquiry card.

SIGNAL GENERATOR. Maker's "Rada-Pulser Sr.," pulse carrier and video pulse generator is the subject of new 2-page leaflet.—Kay Electric Co., 16 Maple Ave., Pine Brook, N. J.

Circle **508** on inquiry card.

TRANSISTORIZED INSTRUMENTS. "Audiolator," a beat frequency audio oscillator; "Minilator," a multi-crystal-controlled oscillator; "Transifier," a small, plug-in, wide-band video amplifier; "Transiprobe," a low capacity RF probe; "Transiply," a tubeless miniature power supply; and "Transvolter," a portable broad-band audio-video voltmeter, are covered in new 4-page Bulletin 9035.—Kay Electric Co., 14 Maple Ave., Pine Brook, N.J.

Circle **509** on inquiry card.

PANEL METERS. New 2-page Data Sheet 268 describes new 1-1/2" flush-mounting panel meter for use on edge-lighted panels.—International Instruments Inc., P. O. Box 2954, New Haven 15, Conn.

Circle **510** on inquiry card.

METERS. Small Panel Meters featuring 250° arc angle and scale lengths up to 2½ times the length of conventional meters, are described in new 6-page Meter Form 250.—The Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland 8, O.

Circle **511** on inquiry card.

OSCILLOSCOPES. Maker's multi-channel oscilloscopes, cathode ray tubes, d-c amplifiers, and strain analyzers, are discussed in new 26-page booklet, "Oscillography."—Electronic Tube Corp., 1200 E. Mermaid Lane, Phila. 18, Pa.

Circle **512** on inquiry card.

TIME-RATE INDICATOR. New 4-page Bulletin 501 provides information on Model 501 digital type frequency meter, also useable for measuring period, time interval, total and ratio.—Laboratory for Electronics, Inc., 75 Pitts St., Boston 14, Mass.

Circle **513** on inquiry card.

TRANSISTORS, TUBES

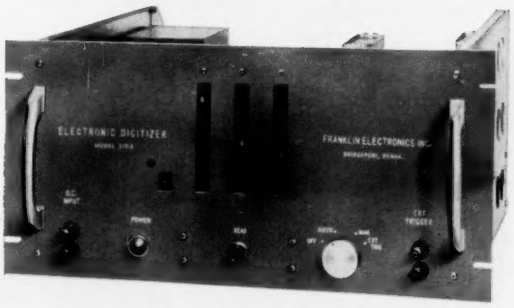
TRANSISTORS. New 3-page Bulletin DL-S 710 describes maker's p-n-p grown-diffused germanium transistor.—Texas Instruments Inc., 6000 Lemmon Ave., Dallas 9, Texas.

Circle **514** on inquiry card.

RECTIFIERS. Models 6894 and 6895 half-wave, mercury-vapor rectifier tubes of the hot-cathode type, for high-voltage rectifier circuits and industrial equipment, are the subject of

NEW ALL ELECTRONIC Digitizer

Provides FAST, Accurate Readings at LOW COST!!



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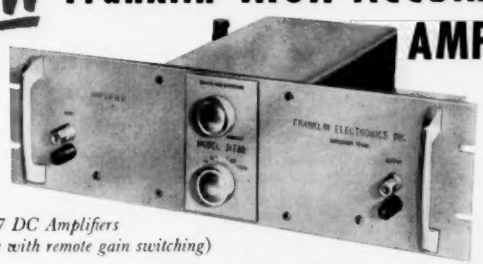

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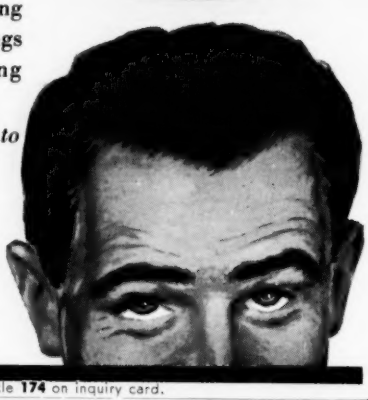

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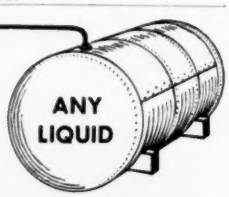

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NEW LITERATURE

10-page Data Sheet 6894, 6895.—Tube Div., Radio Corp. of America, Harrison, N.J.

Circle **515** on inquiry card.

SWITCHES, RELAYS

ELECTROMAGNETIC CONTROLS. New 170-page Catalog 57-S contains information on maker's electromagnetic control equipment. Sections of the catalog are also available separately: Catalog 57-S1—58 pages—transfer switches; Catalog 57-S2—80 pages—remote control switches; Catalog 57-S3—32 pages—magnetically held contactors; Catalog 57-S4—44 pages—relays; Catalog 57-S5—16 pages—a-c and d-c solenoids; Catalog 57-S6—16 pages—plant controls.—Automatic Switch Co., Florham Park, N.J.

Circle **516** on inquiry card.

PROXIMITY SWITCH. Magnetic proximity switch for applications where it is desirable to detect ferrous objects without requiring physical contact, is described in 2-page Data Sheet 119.—Micro Switch, Div. of Minneapolis-Honeywell Reg. Co., Freeport, Ill.

Circle **517** on inquiry card.

D-C RELAYS. Two new 4-page bulletins are available: Bulletin F-3961-7 describes operation of maker's "Micropositioner", polarized d-c relay; Bulletin F-7279 outlines control applications.—Aircraft Controls Div., Barber-Colman Co., Rockford, Ill.

Circle **518** on inquiry card.

MERCURY SWITCHES. New 2-page release 856 provides data on maker's stock switches.—Hamlin, Inc., 1316 Sherman Ave., Evanston, Ill.

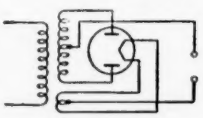
Circle **519** on inquiry card.

CIRCUIT BREAKERS. Featuring new stored energy closing mechanism Magne-blast circuit breakers are described in 6-page Bulletin GED-3337.—General Electric Co., Schenectady 5, N.Y.

Circle **520** on inquiry card.

MULTICONTACT RELAYS. Maker's type 4, enclosed relays; type 9 miniaturized telephone type relays; type 8 telephone type relay, are the subjects of three new 4-page bulletins.—Phillips Control Corp., 59 W. Washington St., Joliet, Ill.

Circle **521** on inquiry card.



POWER SUPPLIES

POWER SUPPLIES. Types 9001, 9102, and 9202, laboratory power supplies are covered in new 4-page brochure.—Burroughs Corp., Electronic Instruments Div., 1209 Vine St., Phila. 7, Pa.

Circle **522** on inquiry card.

POWER SUPPLIES. Thyatron d-c power supplies are presented in new 2-page Bulletin DC T-157.—Dynamic Controls Co., 1955 Massachusetts Ave., Cambridge 40, Mass.

Circle **523** on inquiry card.

POWER SUPPLIES. 'Com-Pak" units in voltage ranges of 0-200, 125-325, 325-525 VDC, are described in new 4-page release, Supplement 1, Catalog 57.—Lambda Electronics Corp., 11-11—131 St., College Point 56, N.Y.

Circle **524** on inquiry card.

TUBELESS POWER SUPPLIES. Data sheets on transistorized dc to dc power converters; high-voltage dc to dc, multi-voltage output transistorized, dc to ac, miniature ac to dc, and transistor power supplies, are contained in 11-sheet portfolio.—UAC Electronics, 50 Bond St., Westbury, L.I., N.Y.

Circle **525** on inquiry card.

POWER SUPPLY. New 2-page bulletin presents maker's "Unireg" Model U32-10 d-c power supply.—Universal Electronics Co., 1720 22 St., Santa Monica, Calif.

Circle **526** on inquiry card.

MAGNETICS

MAGNETIC LAMINATIONS. A discussion of basic design factors, effects of a-c permeability of high-nickle-alloy composition, lamination shape and thickness, etc., are covered in 8-page Reprint, "Applying High Permeability Laminations."—Magnetics, Inc., Sales Engineering Dept., Box 391, Butler, Pa.

Circle **527** on inquiry card.

PERMANENT MAGNETS. New 12-page brochure describes the three vital functions of General Electric's magnetic engineering laboratory.—General Electric Co., Metallurgical Products Dept., Edmore, Mich.

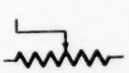
Circle **528** on inquiry card.

MAGNETIC CLUTCHES. Maker's magnetic clutches and brakes are reviewed in new 6-page Bulletin M-101.—Fawick Airflex Div., Fawick Corp., 9919 Clinton Rd., Cleveland 11, O.

Circle **529** on inquiry card.

MAGNETIC CLUTCHES. New 8-page brochure reviews company's offerings of magnetic brakes, clutches, clutch-couplings, clutch-brakes and clutch-brake couplings.—Warner Electric Brake & Clutch Co., Beloit, Wis.

Circle **530** on inquiry card.



RESISTORS

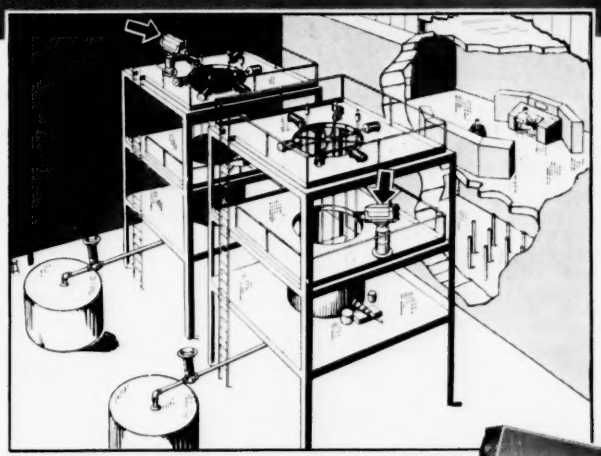
RESISTORS. New 36-page Bulletin GEA-6592 covers maker's full line of vitreous enameled stock resistors.—General Electric, Industry Control Dept., Roanoke, Va.

Circle **531** on inquiry card.

ELECTRONIC PARTS. New 4-page bulletin gives data on resistors, potentiometers, rheostats, switches, etc. distributed by company.—Reliance Merchandizing Co., 2223 Arch St., Phila. 3, Pa.

Circle **532** on inquiry card.

Diamond "UtiliVue" (WIRED TELEVISION) used in NUCLEAR REACTOR STUDIES at Battelle Memorial Institute



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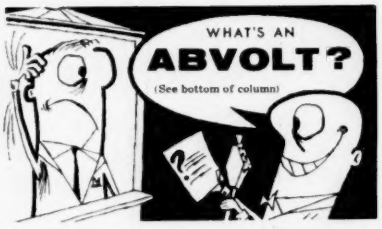

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CERAMICS. Ceramic parts for the electronics industry are subject of new 4-page bulletin.—Electro-Ceramics, Inc., 975 E. 5th S. St., Salt Lake City, Utah.

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ELECTRONIC EQUIPMENT. New 16-page release, "This Month," spring issue, 1957, catalogs electronic relays, meters, powerstats, rectifiers, transformers, switches, etc. distributed by company.—Herbach & Rademan, Inc., 1204 Arch St., Phila. 7, Pa.

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Advertisers' Index

Accuracy Scientific Instrument Co. 1201
Aero Research Instrument Company, Inc. 1201
A'G'A Division of Elastic Stop Nut Corp. of America 1198
Alden Products Company 1178
Allen-Bradley Company 1074
American Chain & Cable Company 1181
American Meter Company 1045
AMP Incorporated 1065
Ampex Corporation 1055
Amthor Testing Instrument Co., Inc. 1161
Applied Science Corp. of Princeton 1214
Armour Research Foundation 1214
Arnoux Corporation 1056
Assembly Products, Inc. 1200
Automatic Switch Co. 1043
Autonetics Division, North American Aviation, Inc. 1191, 1205, 1215
Autotron Co. 1195

Bailey Meter Company 1193
Baldwin-Lima-Hamilton Corporation 1086
Barksdale Valves 1173
Berkeley Division, Beckman Instruments, Inc. 1141
B-I-F Industries, Inc. 1189
Bishop & Co. Platinum Works, J. 1144
Black, Sivalls & Bryson, Inc. 1029
Borg Corporation, George W. 1015
Bridgeport Thermostat Division 1079
Bristol Company 1021, 1058, 1215
Brown Instruments Division of Minneapolis-Honeywell Regulator Co. 1114-1115, 1116-1117, 1118, 1119
Builders-Providence, Inc. 1189
Burgess-Manning Company, Penn Instruments Division 1195

Chace Co., W. M. 1177
Chatillon & Sons, John 1212
Cincinnati Ventilating Company 1176
Cleveland Fuel Equipment Co. 1191
Cohn Corp., Sigmund 1187
Comar Electric Company 1168
Computer Instruments Corporation 1149
C.O.M.S.I.P. 1214
Conoflow Corporation 1066
Consolidated Electrodynamics Corporation 1016-1017, 1041, 1060, 1088
Crescent Insulated Wire & Cable Co. 1131
Curtiss-Wright Corporation 1170

Dahl Company, George W. 1054
Daystrom Systems, Division of Daystrom, Inc. 1028
Decker Aviation Corporation 1051
Development Engineering Company 1194
Diamond Power Specialty Corporation 1213
Dimco-Gray Company 1197
Du Mont Laboratories, Inc., Allen B. 1044
Dynamic Instrument Company Inc. 1152

Eastern Air Devices, Inc. 1159
Edison Industries, Inc., Thomas A., Instruments Division 1025
ElectroData—Division of Burroughs Corporation 1013
Electronic Associates, Inc. 1134
Electro-Pulse, Inc. 1210
Ellis & Sons, Inc., George D. 1214
Emery Company, A. H. 1083
Engineered Electronics Company 1174
Eppley Laboratory, Inc. 1048
Epsco Incorporated 1035
Excel Electric Service Co. 1173

Fairchild Engine and Airplane Corp. 1161
Falstrom Company 1010
Fielden Instrument Division 1027
Fischer & Porter Co. ....Inside Back Cover
Fisher Governor Company 1073
Foxboro Company 1038-1039, 1113
Franklin Electronics, Inc. 1211
Freed Transformer Co., Inc. 1202

Gatti, Inc., Aurele M. 1199
General Electric Company 1049
General Transistor Corp. 1085
Genisco Incorporated 1087
Giannini & Co., Inc., G. M. 1179
Goodyear Aircraft Corporation 1009
Gow-Mac Instrument Co. 1160
Graphic Systems 1178
Gray Instrument Company 1200

Hagen Manufacturing Company, Inc. 1075
Hammel-Dahl Company ....Back Cover
Hankison Corporation 1164
Heiland Instruments 1022
Heise Bourdon Tube Company, Inc. 1209
Helicoid Gage Division 1181
Hetherington, Inc. 1195
Hexacon Electric Company 1208
Hoke, Incorporated 1059

Ideal Industries, Inc. 1046
Illinois Testing Laboratories, Inc. 1158
Instruments Publishing Company 1020, 1040, 1162, 1165
International Business Machines Corporation 1104
International Optical Company, Inc. 1214
International Rectifier Corporation 1189

Johnson Engineering Company, Inc., Welton V. 1018
Jones Optical Works, A. D. 1198

Kay Lab (KIN TEL) 1076
Kearfott Company, Inc. 1171
KIN TEL (formerly Kay Lab) 1076
Klipfel Valves, Inc. 1042
Kurman Electric Company 1202

Leeds & Northrup Company 1080
Lehigh Chemical Company 1180
Levin & Son, Inc., Louis 1057
Lewis Engineering Co. 1032
Lewis Spring & Manufacturing Company 1206
Librascope, Inc. 1157
Lockheed Aircraft Corporation 1153
Logan Engineering Co. 1162
Lynn, Robert M. 1212

Mallory & Co., Inc., P. R. 1023
Manning, Maxwell & Moore, Inc. 1019, 1030, 1062, 1072, 1163
Marsh Instrument Co. 1196
Marshalltown Manufacturing Co. 1160
Meriam Instrument Company 1169, 1215
METAL-IUM Co. 1214
Midwestern Instruments Inside Front Cover
Mine Safety Appliances Company 1089
Mineapolis-Honeywell Regulator Co., Industrial Division 1114-1115, 1116-1117, 1118, 1119
Missile Development Division, North American Aviation, Inc. 1067

Moeller Instrument Company 1052
Moore & Company, Samuel 1070
Moseley Company, Francis L. 1204
Moser Jewel Company 1201

Nash Engineering Company 1024
New Hampshire Ball Bearings, Inc. 1014
New Hermes Engraving Machine Corp. 1196
Nemark Ltd., Louis 1214
Ney Company, J. M. 1166
North American Van Lines, Inc. 1069

Ohmite Manufacturing Company 1031
Opto-Metric Tools, Inc. 1197
Oster Manufacturing Company, John 1148

Palmer Thermometers, Inc. 1172
Panellit, Inc. 1203
Parker Appliance Company 1190
Petrometer Corporation 1168
Phillips & Hiss Co., Inc. 1208
Plummer & Kershaw 1166
Potter Aeronautical Company 1053
Potter & Brumfield, Inc. 1167
Potter Instrument Company, Inc. 1183
Pritchard & Company of California, J. F. 1078

Radio Frequency Laboratories, Inc. 1012, 1026
Reeves Soundcraft Corp. 1151
Renick Co., L. C. 1210
Robbins Aviation 1161

Sanborn Company 1061
Scam Instrument Corporation 1145
Scherr Co., Inc., Geo. 1194
Sensitive Research Instrument Corporation 1010
Servonic Instruments, Inc. 1161
Shallcross Manufacturing Company 1175
Shore Instrument & Mfg. Co., Inc. 1207
Skinner Electric Valve Division 1047
Slaughter Company 1214
Smith Co., S. Morgan 1188
Sorensen & Company, Inc. 1037
Southwestern Industrial Electronics Company 1186
Spar Engineering and Development Incorporated 1147
Stackpole Carbon Co. 1197
Statham Laboratories 1155
Stevens-Arnold Incorporated 1199
Streeter-Amet Company 1194
Stromberg-Carlson 1155
Superior Electric Company 1077
Superior Tube Company 1146
Swiss-American Jewel Bearings Co. 1187

Technical Charts Incorporated 1154
Technique Associates 1196
Testing Machines, Inc. 1205
Thermo Electric Co., Inc. 1184
Thermo-Couple Products Company 1198
Transitron Electronic Corporation 1068
Trimount Instrument Co. 1200

Uehling Instrument Co. 1212
Unertl Optical Co., John 1208
United Electric Controls Company 1050
Universal General see Universal Relay Corp. 1207

Vapor Recovery Systems Company 1182
Veeder-Root Incorporated 1156

Wallace & Tiernan Incorporated 1185
Waugh Engineering Company 1140
Waukee Engineering Company 1199
Weksler Thermometer Corp. 1158
West Coast Electrical Mfg. Corp. 1207
Weston Electrical Instrument Corporation, a Subsidiary of Daystrom, Incorporated 1150
Wolverine Tube Division 1064
Worley Jewel Co., John 1210

Zeiss, Inc., Carl 1063

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TRANSFORMERS. New 4-page Bulletin TR500 describes a line of special commercial transformers—audio, power, r-f, etc.—Laboratory for Electronics, Inc., 75 Pitts St., Boston 14, Mass.

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WIRE

RESISTANCE WIRE. "Karma," "Nichrome," "Nicrome V," and "Advance" alloy wire is described in new 8-page Bulletin 157.—Driver-Harris Co., Harrison, N.J.

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WIRE. Two new 2-page releases are currently available on maker's series 120 lead wire and series 200 hook-up wire.—Philadelphia Insulated Wire Co., 200 N. 3rd St., Phila. 6, Pa.

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WIRE MARKERS. Aluminum foil wire markers are described in new 2-page Bulletin 100-M-8/57.—North Shore Nameplate, Inc., 214-27 Northern Blvd., Bayside 61, N.Y.

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WIRE STRIPPERS. New 2-page Bulletin N-1E describes features of company's new wire strippers, available in two models, designed to strip wire #10 to 26.—Ideal Industries, Inc., Sycamore, Ill.

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MECHANICAL, ELECTRO-MECHANICAL COMPONENTS

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DIE CAST PARTS. New 18-page bulletin gives complete listing of maker's zinc alloy die-cast and thermoplastic molded products.—Gries Reproducer Corp., 125 Beechwood Ave., New Rochelle, N.Y.

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12 31 50 69 88 107 126 145 164 183	212 231 250 269 288 307	412 431 450 469 488 507 526 545
13 32 51 70 89 108 127 146 165 184	213 232 251 270 289 308	413 432 451 470 489 508 527 546
14 33 52 71 90 109 128 147 166 185	214 233 252 271 290 309	414 433 452 471 490 509 528 547
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21 40 59 78 97 116 135 154 173 192	221 240 259 278 297 316	421 440 459 478 497 516 535 554
22 41 60 79 98 117 136 155 174 193	222 241 260 279 298 317	422 441 460 479 498 517 536 555
23 42 61 80 99 118 137 156 175 194	223 242 261 280 299 318	423 442 461 480 499 518 537 556
24 43 62 81 100 119 138 157 176 195	224 243 262 281 300 319	424 443 462 481 500 519 538 557
25 44 63 82 101 120 139 158 177 196	225 244 263 282 301 320	425 444 463 482 501 520 539 558

NEW LITERATURE

WING NUTS. Two new stock sheets list maker's line of zinc-alloy wing nuts.—Gries Reproduction Corp., 128 Beechwood Ave., New Rochelle, N. Y.
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METAL HOSE. Applications, uses, specifications, sizes, etc., of metal hose and bellows are contained in new 16-page Catalog 156.—Flexonics Corp., 1337 S. 3rd Ave., Maywood, Ill.
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DIAMOND PIVOTS for electrical indicating instruments, with calibrated-spring shock mounted jewels, are presented in new 2-page bulletin.—Sensitive Research Instrument Corp., New Rochelle, N.Y.
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METAL PARTS. Maker's line of standard lugs, clips, terminals, wire forms and other small parts, are listed in 44-page Catalog 21.—Zierick Mfg. Corp., Beechwood & Rockdale Aves., New Rochelle, N.Y.
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S. S. FASTENERS. Maker's line of stainless steel screws, hinges, screw machine products and related items are covered in new 24-page Catalog 56-A.—Star Stainless Screw Co. 655 Union Blvd., Patterson 2, N.J.
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METAL TUBULAR PARTS. New 4-page Bulletin 2056 describes company's facilities for the fabrication of precision tubular parts.—H & H Machine Co., Inc., Noble & Jackson Streets, Norristown, Pa.
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WELDED BELLOWS. New 8-page Catalog 2 covers welded bellows in stainless steel and similar alloys.—The Belfab Corp., Agawam, Mass.
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MATERIALS

GLASS. Data on mechanical, thermal, electrical and chemical properties, heat transmission etc. for several commercial glasses, are contained in new 16-page Bulletin B-83.—Corning Glass Works, Corning, N.Y.
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OPTICAL GLASS. New 4-page bulletin describes some aspects of company's production of glass for massive optics.—Hayward Scientific Glass Corp., 217 Magnolia Ave., Whittier, Calif.
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SILICON. New 20-page monograph, "The Relationship of Silicon and its Properties to the Electronics Industry," describes characteristics of silicon in rectifiers, solar batteries, transistors, etc., and the methods of device fabrication.—Aries Laboratories, Inc., 41 E. 42 St., New York 17, N.Y.
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MISCELLANEOUS

DRAFTING ROOM EQUIPMENT. New 4-page folder discusses features of maker's drafting equipment.—Frederick Post Co., 3650 N. Avondale Ave., Chicago 18, Ill.
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ENGINEERING INSTRUMENTS. Equipment for engineering and surveying is listed in maker's revised 72-page Catalog 50.—W. & L. E. Gurley, Troy, N.Y.
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METER PROTECTION. New 2-page bulletin presents features of company's "meter guard," for use with Simpson, 260, 303, 276 or 380 instruments.—Electronic Development Labs. 71 Nassau St., New York 38, N.Y.
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ELECTRONIC DEVELOPMENT. New 4-page Bulletin 571-3 discusses company's design and development services.—Strand Engineering Co., 1354 N. Main St., Ann Arbor, Mich.
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RESEARCH SERVICE. New 4-page bulletin describes industrial research and development services offered by company.—Bussey Research Laboratories, Inc., Bld. 629, Greater Rockford Airport, Rockford, Ill.
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FABRICATION

ROTARY CUTTING TOOLS. New 12-page bulletin contains information on maker's complete line of carbide rotary tools.—Elgin National Watch Co., Elgin, Ill.
Circle 570 on inquiry card.

ULTRASONIC CLEANER. New 2-page Data Sheet 3009 presents features of maker's new ultrasonic cleaner Model 3009.—Alcar Instruments, Inc., 17 Industrial Ave., Little Ferry, N.J.
Circle 571 on inquiry card.

MANUFACTURING FACILITIES. New 4-page bulletin lists precision manufacturing facilities of—Bristol Instrument Gears, Inc., 11 Union St., Bristol, Conn., and Carros and Hart, 13 Union St., Bristol, Conn.
Circle 572 on inquiry card.

CUT-OFF MACHINES Cut-off machines for cemented carbides, tile, ceramics, etc. are the subject of new 2-page Bulletin CDG 7463; maker's segmented type diamond abrasive blades for cutting concrete, marble, granite, etc. are covered in new 2-page bulletin CDG 7296.—Felker Mfg. Co., 1128 Border Ave., Torrance, Calif.
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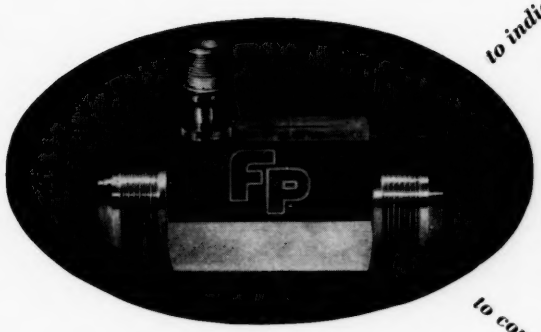
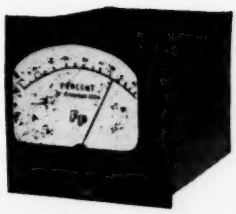


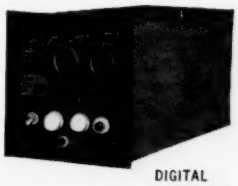


PANEL FLOW RATE INDICATOR

to indicate flow

to indicate steady state flow condition

IN-LINE DIGITAL INDICATOR



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to convert transient flow for analog output

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"IN-LINE" DIGITAL INDICATOR: Direct digital readout of flow information in desired gravimetric or volumetric units. Automatically selects turbine meter outputs by flow range.

DIGITAL TOTALIZER: Provides integrated flow information accurate to ½%.

FREQUENCY MULTIPLIER-CONVERTER: Extremely rapid response to transient flow signals. Sampling of eight points per cycle provides more information than conventional means.

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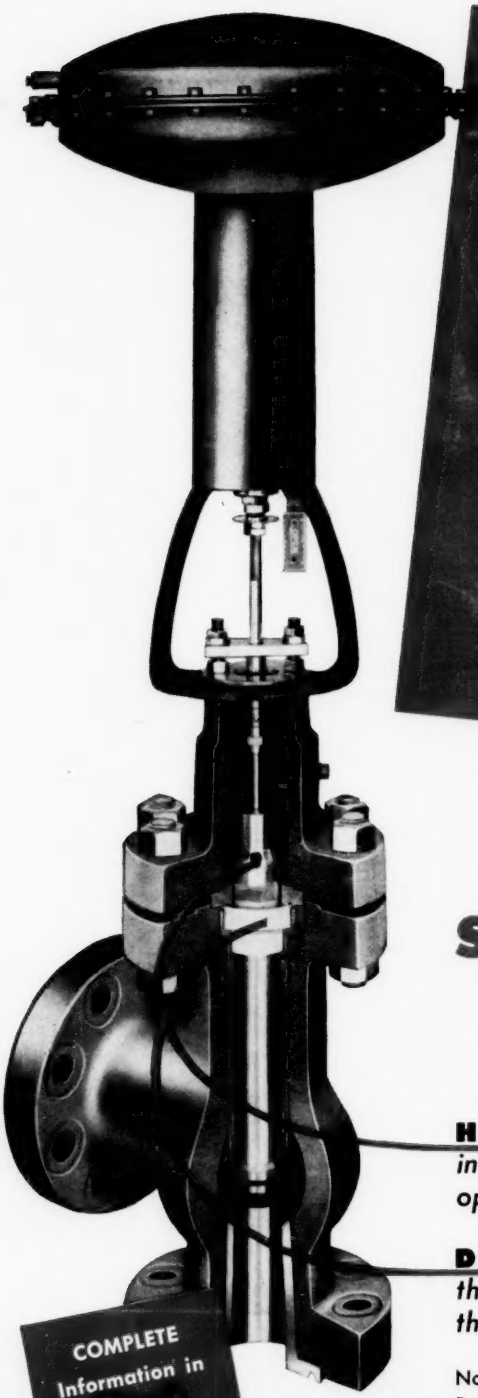

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